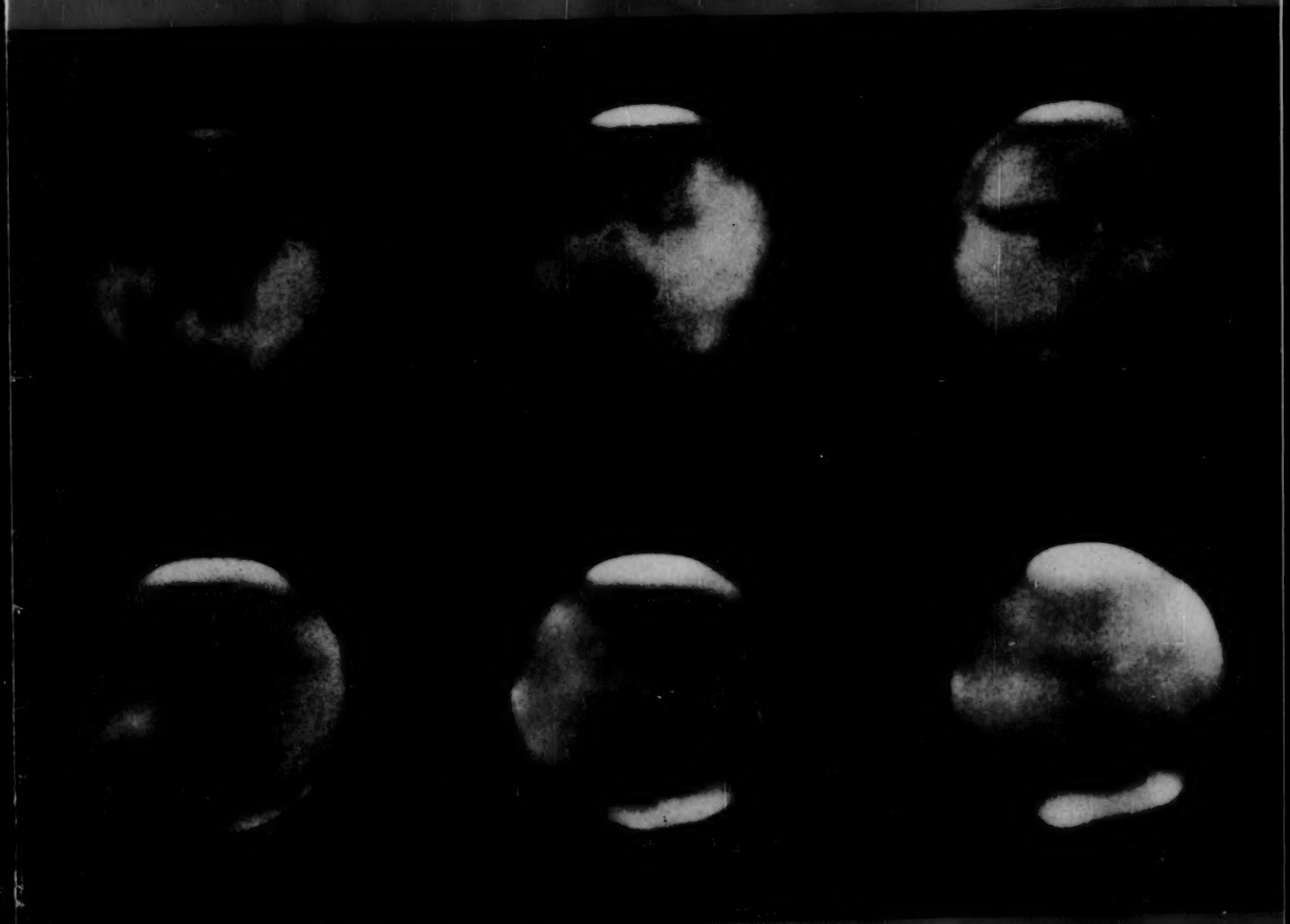
Sky and TELESCOPE



Blue clearing on Mars

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Vol. XIV, No. 9

JULY, 1955

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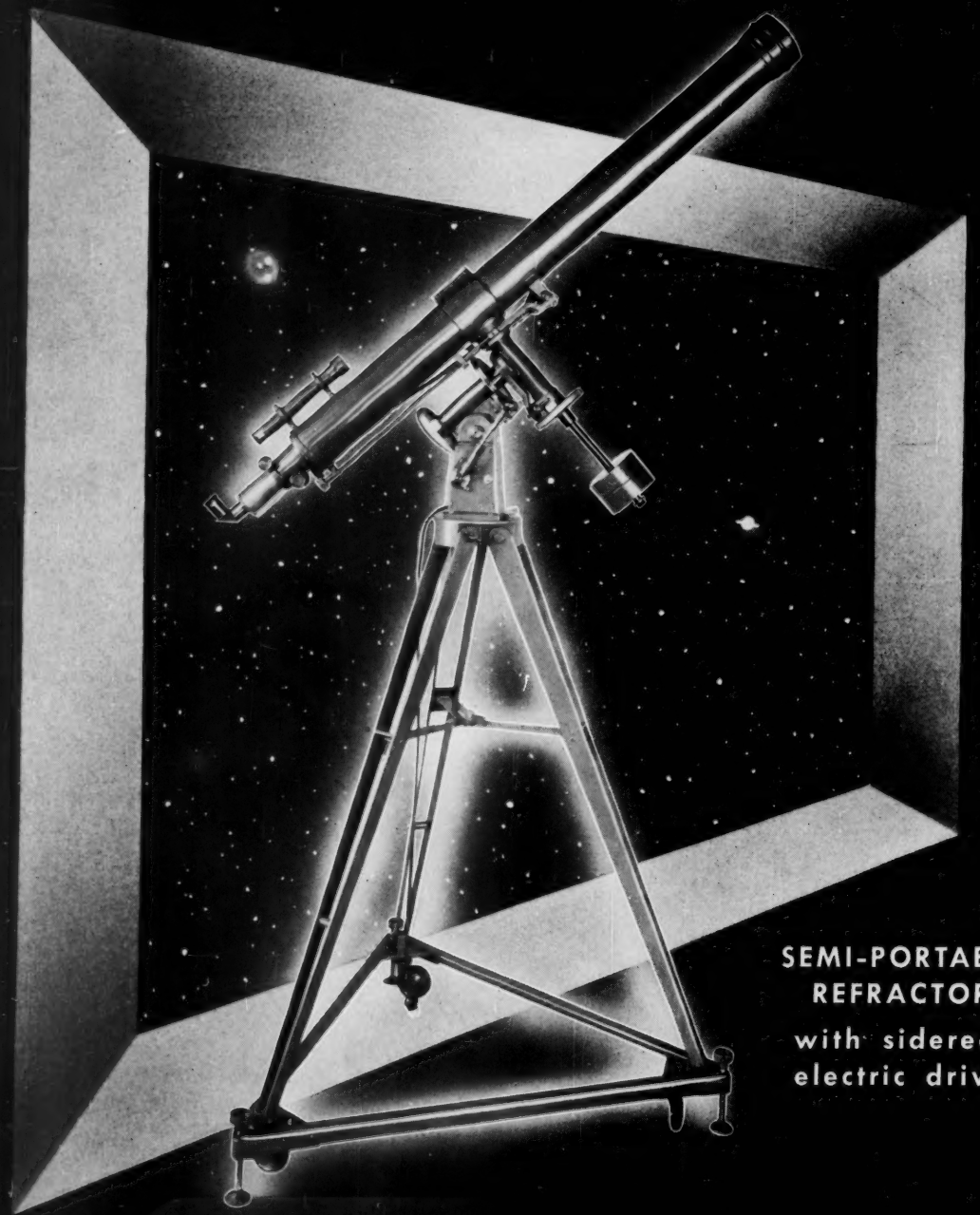
a NEW LOOK at the universe . . .



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Sky and TELESCOPE

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Boyden Station Research To Continue

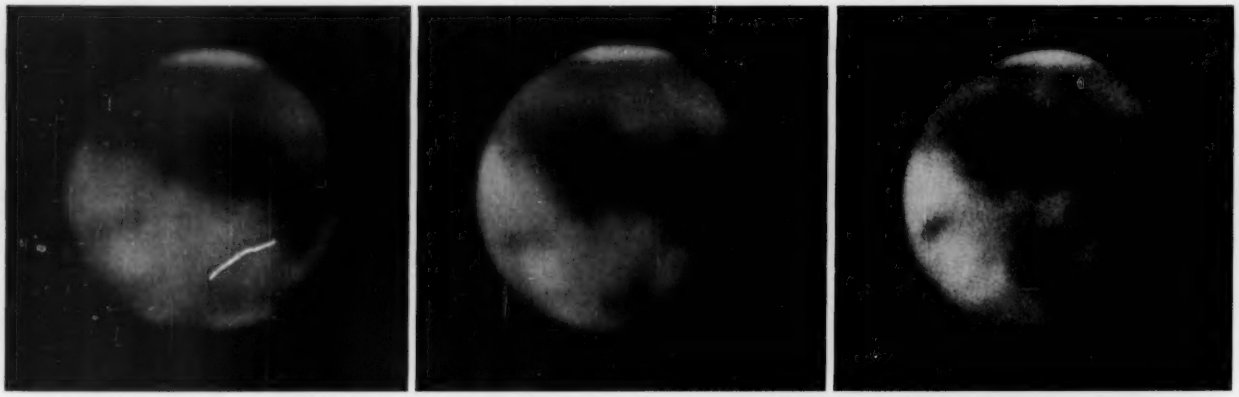
AN AGREEMENT has been reached between Harvard Observatory and a group of European observatories concerning the future operation of the Boyden station near Bloemfontein, Union of South Africa. The arrangement was first discussed at a meeting in Hamburg in the summer of 1954 by the director of Harvard Observatory on the one hand, and the directors of the observatories of Armagh, North Ireland; Dunsink, Irish Republic; Hamburg, West Germany; Stockholm, Sweden; and Uccle, Belgium (as representatives of the astronomical institutions of their various countries) on the other. In May, 1955, the directors of the European observatories met again in Uccle to discuss further details.

The Boyden station was first established in Arequipa, Peru, in 1890, as an outpost of Harvard Observatory. The station was transferred to Mazelspoort, near Bloemfontein, in 1927, where a 60-inch reflector was mounted as a companion to the 61-inch telescope at Harvard's George R. Agassiz station in Massachusetts. In recent years, a 32-inch flat-field Schmidt telescope, designed by Dr. James G. Baker, was jointly acquired by the Armagh, Dunsink, and Harvard observatories and mounted in place of the famous 24-inch Bruce wide-field refractor.

The joint operation of this instrument by these three observatories marked the first step in international co-operation at the Boyden station. The ADH telescope has already contributed much to the study of the structure of the galaxy, very important portions of which can be seen only from the Southern Hemisphere. In addition to brilliant regions of the Milky Way, the southern sky contains the Large and Small Magellanic Clouds, some of the brightest globular clusters, and numbers of nearby and distant galaxies. A large part of our knowledge of southern galaxies, variable stars, and spectra of southern stars, comes from photographs taken at the Boyden station.

In spite of this wealth of astronomical data obtained at Bloemfontein, Harvard Observatory has been forced through lack of funds to withdraw from the sole support of the Boyden station. On account of the extreme importance of astronomical activity in the Southern Hemisphere and the exceptionally favorable meteorological conditions that prevail around Bloemfontein, the group of European observatories mentioned earlier has agreed to step into the breach to supply the funds necessary for the continued opera-

(Continued on page 373)



A striking change in the Martian surface is revealed in these photographs, taken in 1907 (left) at Lowell Observatory, and in 1939 and 1954 at the Lamont-Hussey Observatory by E. C. Slipher. All three pictures show the same face of Mars, and the very dark triangular feature, Syrtis Major, is visible in each case near the right edge. The area a little below the center of the disk, and to the left of Syrtis Major, was almost featureless in 1907, but by 1939 there had become conspicuous there a dusky curved band, Thoth-Nepenthes. Finally, in 1954 a huge dark region had developed, the greatest alteration in the surface of Mars since it was first mapped 125 years ago. Lowell Observatory photographs.

NEW FINDINGS ABOUT MARS

WILLIAM M. SINTON, *Harvard College Observatory*

IF THE MARTIANS of the science fiction writers felt self-conscious this past year, it was because their planet had never before been so thoroughly observed by the people of Earth. The 1954 opposition marked the organization of a world-wide photographic patrol to keep Mars under constant surveillance, introduction of television techniques to make better photographs, use of the 200-inch telescope for radiometric observations, and application of motion-picture photography to obtain exposures during moments of superseeing. This multi-pronged attack on Martian problems has been most fruitful.

The International Mars Committee is an informal group of astronomers, meteorologists, and physicists, organized in 1953 to plan observations of the red planet. Because oppositions as favorable as those of 1954 and 1956 had not occurred since 1939 and 1941, and will not recur until 1969 and 1971, it was desirable to arrange beforehand as complete coverage of the planet as possible, both in time and in methods of observation. Some of the plans were reported in *Sky and Telescope*, June, 1954, page 251.

The results of this planning were reported at the fourth meeting of the Mars committee, at Flagstaff, Ariz., on March 24th this year. Some of the significant new facts discovered during the 1954 opposition are presented here, while the most important results are perhaps still to appear.

Following a program drawn up by the Mars committee, and with financial aid from the National Science Foundation, seven observatories well distributed in geographical longitude observed Mars nearly continuously from May 1, 1954, to September 15th. On those dates the apparent diameter of Mars was 13.4 seconds of arc, while on July 2nd the planet attained its largest diameter of 21.9 seconds.

Since Mars has a rotation period nearly the same as the earth's, features at a particular longitude on that planet are visible to any one terrestrial observatory only for short intervals of several days, and then they do not return to the same relative position for nearly 40 days. For this reason, such phenomena as cloud formations cannot be followed night after night from one observatory alone. A chain of observatories spaced around the world is needed to keep all areas of Mars under constant scrutiny.

MARS PATROL OBSERVATORIES

Observatory	*Long.*	*Lat.*
Bosscha, Java	108°E	7°S
Kodaikanal, India	77°E	10°N
Helwan, Egypt	31°E	30°N
Lamont-Hussey, S. Africa	26°E	29°S
Pic du Midi, France	0°	43°N
Eva Peron, Argentina	58°W	35°S
Lowell, U.S.A.	112°W	35°N
OTHER CO-OPERATING OBSERVATORIES		
Carter, New Zealand	175°E	41°S
Commonwealth, Australia	149°E	35°S
Tokyo, Japan	140°E	36°N
Kwasan, Japan	136°E	35°N
Union, S. Africa	28°E	26°S
McDonald, U.S.A.	104°W	31°N
Palomar, U.S.A.	117°W	33°N
Griffith, U.S.A.	118°W	34°N
Mount Wilson, U.S.A.	118°W	34°N
Lick, U.S.A.	122°W	37°N

The accompanying list gives the observatories that co-operated in the patrol. Others with similar programs, but not formal stations of the patrol, are given in the lower half of the list. The patrol observatories received plates, filters, and enlarging lenses from the Mars committee, to enable them to observe with their refracting telescopes under as nearly similar conditions as could be arranged. Photographs in blue light were made with Eastman 103-O plates; yellow pictures were taken with 103-G plates and a Wratten 12 filter; red pictures, with 103-E plates and a Wratten 29 filter. The magnification of Mars' image was as large as possible consistent with the condition that the exposure time be two seconds or less.

The chart shows the yellow and red photographic coverage of Mars achieved by the patrol during the opposition, but it does not include the list of plates taken at the Eva Peron Observatory in Argentina. Each horizontal line on the chart indicates one plate, which may have as many as 10 to 100 images of Mars on it. The length of the line shows the range of Martian longitudes that crossed the center of the disk while the exposures were being made. Thus, on June 30th Mars was well photographed when the longitude of the central meridian lay between 0° and 130° and between 230° and 260°. The two gaps of 100 degrees are caused by the Atlantic and Pacific Oceans; the Argentine observations should help fill the gap caused by the Atlantic. For 1956, an ob-

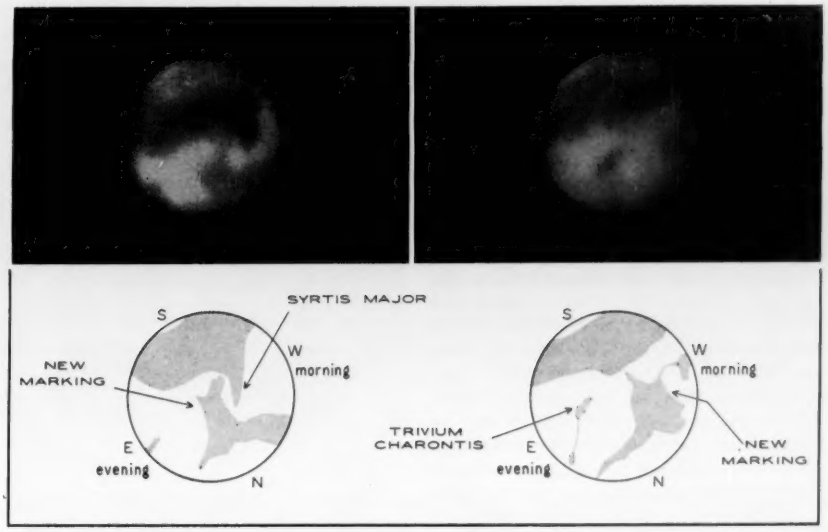
servatory will be needed on some Pacific island, for a 100-degree gap is too large.

The coverage with blue photographs is unfortunately rather poor. The only observatories of the patrol having blue correcting lenses for their refractors were Lowell and Lamont-Hussey.

The National Geographic Society sponsored the Lowell Observatory expedition to Bloemfontein, South Africa. There the veteran Mars observer, E. C. Slipher, made an impressive record with the 27-inch refractor of the Lamont-Hussey Observatory. Using with this telescope an auxiliary lens that increased the effective focal length to 217 feet, he obtained 20,000 photographs of Mars in blue, yellow, and red light. Out of 130 available nights, only six were lost to poor observing conditions. There was not a single night missed in the last 92—probably a record for continuous planetary observing. Dr. Slipher states that 50 per cent of his pictures are of high quality and 70 per cent are extremely useful.

Several new Martian phenomena were recorded on the Slipher photographs. In past years, the blue haze that normally obscures the surface features had sometimes disappeared, always abruptly and for a few days only. In 1954, however, the blue haze was semitransparent from the time observations began in May until July 2nd, when the Martian atmosphere once again became opaque to blue light. During the semitransparent phase, Dr. Slipher was first able to photograph cloud belts on the planet—an entirely new Martian phenomenon (see the picture on page 363).

The blue clearing and its disappearance are demonstrated in the front-cover pictures. The left-hand pair of photographs was taken during the clearing, on June 13, 1954, in red light (above) and blue light. The red picture shows rich detail, with triangular Syrtis Major large and dark in the center of the disk. Since the Martian atmosphere is substantially transparent to red and yellow light, this image and the two others on the upper row show surface rather than atmospheric features. Photographs in blue light, on the other hand, ordinarily show only atmospheric veiling and clouds. Nevertheless, because of the clearing the blue picture of Mars on June 13th shows dimly the main dark areas such as Syrtis Major.



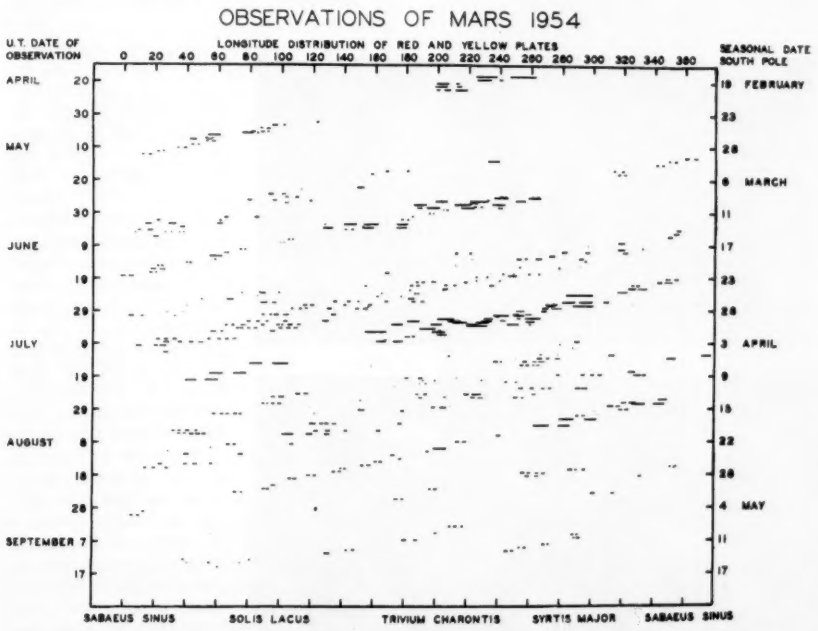
These Mount Wilson photographs show the new dark marking that appears in the series of pictures opposite. They were made in yellow light at the coude focus of the 100-inch reflector, July 2, 1954, at 9:55 UT, and July 3, 8:01. On the original negatives the images of Mars are eight millimeters across.

The middle pair of pictures was taken July 4th, after the end of the blue clearing. In the yellow exposure, above, there is abundant surface detail, notably the large and very dark Mare Acidalium at the lower left edge of the planet. On the matching blue image these markings cannot be made out.

Similarly, the third front-cover pair of Mars photographs, orange light above and blue below, on July 9th, shows the usual veiling. In the orange picture, Sinus Sabaeus is the very dark strip running rightward to the center, where it ends in Dawes Forked Bay; only the merest trace shows in blue light.

The July 2nd date for termination of the blue-light clearing at this opposition was confirmed at Mount Wilson Observatory, by Edison Pettit and Robert S. Richardson. They used a Mitchell motion picture camera at the coude focus of the 100-inch reflector and with an enlarging lens at the Cassegrainian focus of the 60-inch reflector. It was their hope that by taking a large number of short exposures during good seeing some of the pictures would record the elaborate canal system during the rare moments of superseeing. Their exposures on fine-grain emulsion ranged from 1.2 seconds in blue light at the 60-inch to 0.2 second in yellow light at the 100-inch. From April 18th to July 5th, they observed on 20 nights for a total of 41 hours, securing 4,700 yellow images and 3,200 blue images, of which 40 per cent were rated "fair plus" or "good." At opposition, Mars' diameter on the film was eight millimeters.

The only photographs examined for canals were those of July 1-3 in yellow



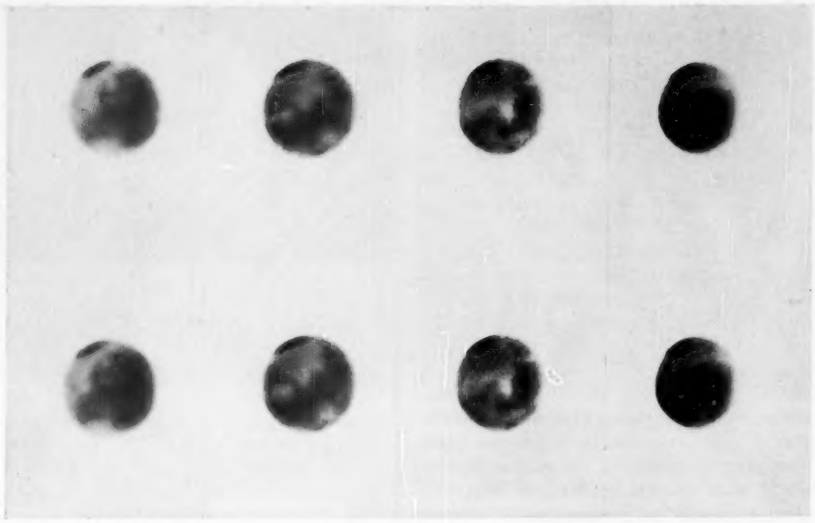
This is a chart of the work of the photographic Mars patrol. The right-hand scale gives the Martian date, and the upper scale is the Martian longitude of the center of the disk. Compiled by the International Mars Committee.

light, taken during good seeing, when Mars was 39.8 million miles away. Markings readily visible on scores of exposures were identified with the canals Cerberus I, Hades, Eunostos I, Hyblaeus, Thoth-Nepenthes, and Gyndes-Alcyonius.

The Mount Wilson photographs show one of the most surprising changes on Mars in over a century, also evident in Slipher's pictures. Since the 1952 opposition, a huge area near the Thoth-Nepenthes canal has changed from the normal orange-red color to the dark tint of the maria. Roughly twice the size of the island of Madagascar, the new area has developed in one Martian year. Smaller changes in this general region of the planet have been under way for some time; Thoth-Nepenthes itself used to be very difficult to see, but in recent years it has broadened so much that it is hardly to be classed as a canal any longer.

An odd cloud, shaped somewhat like the letter W, was discovered on the sunset limb of Mars by Pettit and Richardson on their blue photographs of June 2 and 3, 1954. It did not show on yellow photographs. On July 3rd, when the same region of Mars could again be seen at the sunset limb by the Mount Wilson astronomers, the cloud was still there. Had it persisted for a month? Watching the same region on intervening dates, Slipher in South Africa found the cloud to be present only during the Martian afternoon. It did not show on pictures taken when the area was at the morning limb of the planet. Thus, the cloud very likely re-formed every afternoon and disappeared every night for a month. Only observations made on an international scale could have uncovered this important fact.

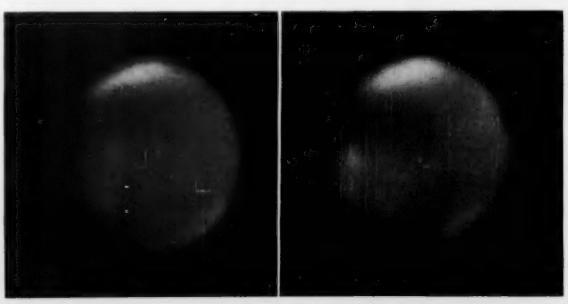
At the three intersections of the W, Pettit and Richardson discovered bright knobs, and there is a fourth bright knob at one end, as shown in the photographs reproduced here. With the aid of the 1954 Mars map published by the Association of Lunar and Planetary Observers, these knobs were found to correspond roughly in position with the oases Arsia Silva, Ascraeus Lacus, Tithonius Lacus, and Hebes Lacus; two of the strokes of the W correspond to the canals Ulysses and Fortunae. The apparent matching may nevertheless be accidental.



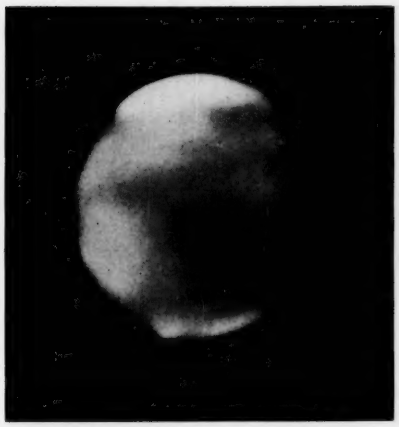
Enlargements of Kodachrome photographs of Mars, printed as negatives to avoid adding grain in copying. The 26½-inch visual refractor of the Union Observatory, Johannesburg, was stopped down to 13¼ inches for these pictures by W. S. Finsen, J. Churms, and P. C. Seligmann, who used a Paillard Bolex cine camera, Barlow lens, and a beam splitter for focusing and guiding. Exposures were 3.0 and 4.0 seconds. The pairs were taken, left to right, July 1, 1954, 21:07 UT; July 5, 20:20; July 14, 19:01; and July 23, 18:26. The longitudes of the Martian central meridian were 74°, 29°, 289°, and 199°, respectively. Union Observatory photographs.

At Palomar Observatory, John Strong, of Johns Hopkins University, and the writer made temperature measurements of Mars with the 200-inch Hale telescope. Nearly 30 years have elapsed since the last extensive radiometric observations of the planets were made, and in recent years infrared techniques have developed rapidly. Dr. Strong and I have been applying these new methods to the radiometry of the planets. For our 1954 work on Mars we used a Golay detector, a development of World War II. It is a somewhat more sensitive detector of heat radiation than the thermocouples used by pioneer investigators.

We found that the daily maximum temperature on Mars occurs from 15 to 30 minutes after local noon, and at the equator this maximum temperature is 25° centigrade (77° Fahrenheit). On the



Two views of the W-shaped cloud at the sunset edge of Mars, on June 3, 1954, at 8:28 and 10:04 UT. These are Mount Wilson photographs in blue light, taken with the 60-inch reflector. Below are three blue-light photographs by E. C. Slipher, in South Africa. Left to right, on June 20th and 26th the W is seen at the sunset (left) edge. When this region of Mars was to the right of the planet's center, however, and was having morning, there is no trace of the cloud (right-hand picture, July 4th). This and other pictures prove that the W re-formed each afternoon.



Atmospheric belts roughly parallel to the Martian equator are seen in this blue-light exposure by E. C. Slipher on July 18th in South Africa.

other hand, the sunrise temperature at the same location is at least as low as −50° centigrade (−58° Fahrenheit). We also measured the temperature of a large yellow cloud at the sunset limb on July 20th. It is known that this cloud was present the previous day, and it is hoped that between these times one of the patrol stations will have photographs of the cloud as a projection on the planet's terminator. This would permit measuring the cloud's height, and—its temperature being known—the rate of decline of temperature with height in the Martian atmosphere could be established.

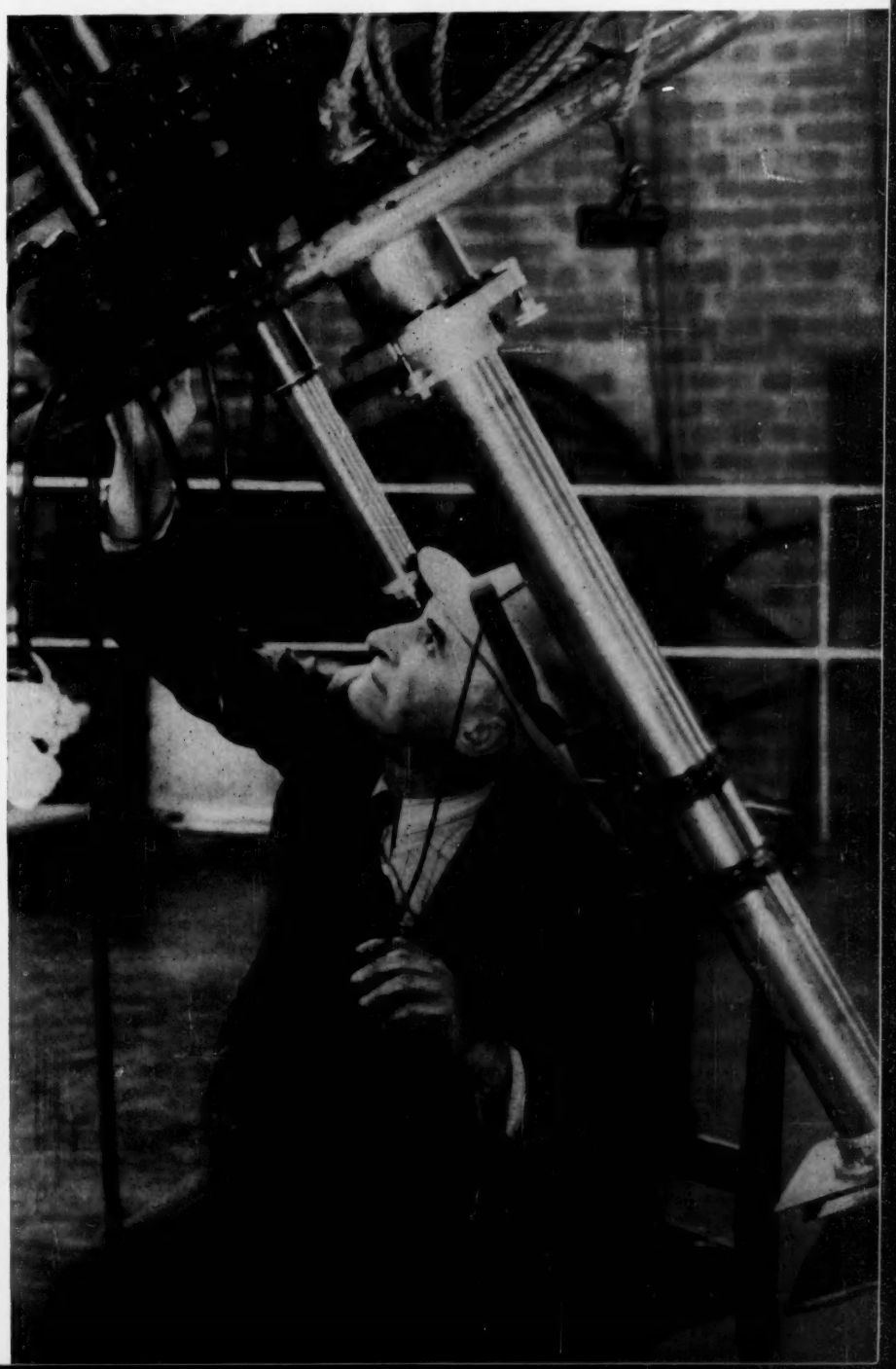
A unique development in planetary observing was the use of television equipment on the Lowell Observatory's 24-inch refractor, by Ralph Sturm, Johns Hopkins University, and Albert G. Wilson, director of Lowell. This equipment was originally developed for fluoroscopic X-ray work at the Johns Hopkins Hospital under the direction of Dr. Russell H. Morgan. It brightens the dim images of the fluoroscopic screen to save examining time and protect both the doctor and the patient. The device differs from ordinary television chiefly in having a very powerful amplifier for the extremely weak signals and in giving a sharper picture of 1,029 lines instead of the usual 525.

Using this equipment, it is only necessary to photograph the picture tube with an ordinary camera. Because of the high quantum efficiency of the Orthicon pickup tube (see page 227 of the April issue), an exposure can be made in 1/30 the time required by ordinary photography. In the case of Mars, there was a 10½-millimeter image on the cathode of the Orthicon tube, and the exposure time was only 1/15 second through a red filter.

The sharpness of the pictures taken with this system gives promise that, with some improvements, in 1956 it will yield photographs of the elaborate system of canals. Plans call for using the image intensifier, as this equipment is called, on the Lamont-Hussey 27-inch refractor. It is intended to have 1,000 lines across the image of Mars instead of the 250 used in 1954, and to try exposures of less than 1/30 second.

There have been many important observations of Mars in 1954 that could not be included in this brief summary. Much of the work has not been reported yet, particularly that done abroad, and not until all the observations are compared and correlated will many of the most important developments be discovered. The value of the photometric and polarimetric work will not be exactly known until it is combined with the other types of observations. When meteorologists analyze the data concerning the Martian atmosphere, many new facts about the meteorology of Mars will be obtained.

Most important, the experience gained at this opposition will allow the best possible preparations for the 1956 approach of Mars, when the planet will attain 97 per cent of its maximum possible apparent diameter.



E. C. Slipher looks through the guiding eyepiece of the 27-inch Lamont-Hussey refractor, fitted with an enlarging camera for planetary work. This picture was taken in 1939, on an expedition to South Africa to observe Mars with the same telescope he used last year. Dr. Slipher's planetary observations at Lowell Observatory extend back to 1906.

The Star of Smallest Known Mass

SARAH LEE LIPPINCOTT, *Sproul Observatory, Swarthmore College*

DURING the 19th century, the discovery of companion stars to both Sirius and Procyon was an outstanding event in positional astronomy. In 1844, Bessel found that these stars were not following straight paths on the sky. It appeared that Sirius was revolving about an invisible point that was moving through space in a straight line. The amplitude of the oscillation of Sirius against the sky background is about three seconds of arc, 10 times the yearly parallactic displacement Bessel had found for 61 Cygni six years earlier.

Bessel ascribed the deviation from uniform rectilinear proper motion for Sirius, and similarly for Procyon, to an unseen companion. It is the center of mass of the two stars that moves in a straight line in space as a single star normally would move, and the two individual stars describe orbital motions about this center in similar ellipses, but differing in orientation by 180 degrees. Bessel's interpretation was, of course, based on the well-known Kepler motion of two bodies, in agreement with Newton's law of gravitation.

For Sirius, visual confirmation came 18 years later, in 1862, when Alvan G. Clark was observing with the newly constructed 18½-inch telescope that was later installed at Dearborn Observatory. He found the companion of Sirius to be about 8th magnitude, only 1/6,000 as bright as Sirius itself; the two stars require 50 years to revolve around each other. It was not until 1896 that Procyon B was seen with the 36-inch Lick refractor by J. M. Schaeberle. In both cases it is primarily the large difference in magnitude, and not the distance apart, that brings about the great difficulty in observing the two components separately.

Later, a number of other stars were discovered to have variable proper motions, but until the case described in this article none of their companions had actually been seen or photographed.

Since 1937 the Sproul Observatory has been determining very accurately the proper motions and parallaxes of a selection of nearby stars, with the hope of discovering small deviations from rectilinear proper motion for some of these stars. In order that perturbations of very small amplitude be detected, many more photographs must be taken than are required for conventional parallax determinations. The Sproul program has already resulted in the finding of several unseen companions, and their photocentric orbits have been determined (*American Scientist*, *42*, 572, 1954, and *Popular Astronomy*, February to May, 1951).

The inconspicuous 11th-magnitude red dwarf star, Ross 614, only 13 light-years away, had showed a perturbation in its proper-motion path, from measures on a series of parallax photographs taken some two decades ago at the McCormick Observatory; obviously the star was not moving alone. The period and amplitude of this apparent oscillation were not well known, due to lack of observations over a sufficiently long interval; no conclusive statements could be made about the unseen companion at that time, except that it must be a stellar lightweight.

But by 1950 the time was ripe to make use of the McCormick observations from 1932 to 1937 and Sproul photographs of 1938-1950. The positions of the image of Ross 614 were measured, referred to the images of four distant background stars appearing in the field. It was found that more than one revolution had been completed, so that a definitive orbit could now be derived. The image midpoint or photocenter of the Ross 614 system revolves with a period of 16.5 years about a point that marks the center of mass of the double star system. The semi-major axis of this photocentric orbit is 0.31 second of arc, or 1.22 astronomical units at a distance of 13 light-years from the sun.

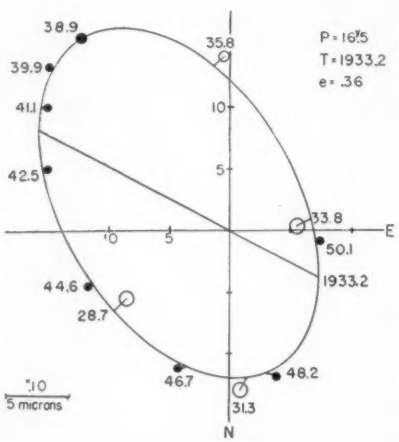


Fig. 1. The photocentric orbit of Ross 614, published by the author with her analysis of the orbit ("Astronomical Journal," February, 1951). The period is 16.5 years, periastron passage 1933.2, and orbital eccentricity 0.36. The year is given for each point, with "19" omitted. The dots represent Sproul normal points, the open circles are McCormick normal points; the radius in each case indicates the probable error. Sproul Observatory diagram.

The photographic image of Ross 614 taken with the Sproul refractor has an average diameter of 2½ seconds of arc (2".5). This diffusion disk has nothing to do with the true dimensions of the star itself, but primarily with the chemical process of building up an image on the photographic emulsion. If star B contributed no light to the photographic image, the orbit of the photocenter would be strictly that of star A about the center of mass. But if B is bright enough to build up an image of its own, the separation of the two components must be less than about two seconds of arc, since the B component is not observed separately on the Sproul photographs. In this case, we are observing a combination of two light sources, and the composite image is displaced from the position of the brighter star, A, toward B (and therefore toward the center of mass) by an amount depending on the relative brightnesses of A and B and the distance between them. This means that until the difference in magnitude of the components of Ross 614 became known, we could not tell whether the photographic image represented the light from the A image only, or some combination of A and B.

If the companion star contributes some light, then the photocentric orbit, which is the orbital path of the combined light of the two stars, is smaller than the orbit of star A about the center of mass. It follows geometrically that the three orbits, of star A, star B, and the photocenter, are similar, differing only in size and in their phases.

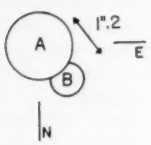
A number of attempts to see the elusive companion with the 24-inch Sproul refractor have failed. From the photocentric orbit (Fig. 1) we predicted 1955 as the most favorable time for visual detection, because the separation of the two stars would then be greatest. We

wrote Dr. Walter Baade, at Mount Wilson and Palomar Observatories, who said he would endeavor to observe the unseen star with the Hale telescope. He had four nights during the month of February with the 200-inch at his disposal. The weather was miserable; the confusion disk was something like five seconds of arc. We anxiously waited, while Ross 614—which is in the constellation of Canis Major—was rapidly going out of the night sky for the season.

Three more chances in March! First, poor seeing; second, still poor seeing; and then the last chance for perhaps 16 years. Conditions on that third night, March 23, 1955, were favorable, and Dr. Baade saw the companion of Ross 614. It was at the position angle we had predicted, and thus became the third such object finally seen, 59 years after the visual discovery of the companion of Procyon.

Dr. Baade succeeded in obtaining some photographs of the two stars, exposures

Fig. 2. Three successive five-second exposures of Ross 614, taken by W. Baade with the 200-inch telescope, March 23, 1955. The faint companion is visible at position angle 36°, at the time of its greatest elongation. This is a 20-times enlargement from the original negative, on which the scale was 11.12 seconds of arc to one millimeter. Mount Wilson and Palomar Observatories photo.



ranging from 2½ to 10 seconds (Fig. 2); since Ross 614B does not appear on exposures of only one second, he estimates the apparent magnitude to be 14.8, 3½ magnitudes fainter than the A component. The absolute magnitude is 16.8, with a probable error of half a magnitude, which gives this star second place in order of faintness. The five faintest stars known to date are, in order of absolute visual magnitude:

Van Biesbroeck's star	19.3
Ross 614B	16.8
Wolf 359	16.6
Luyten 726-8B	16.1
Luyten 726-8A	15.6

The measured separations of the

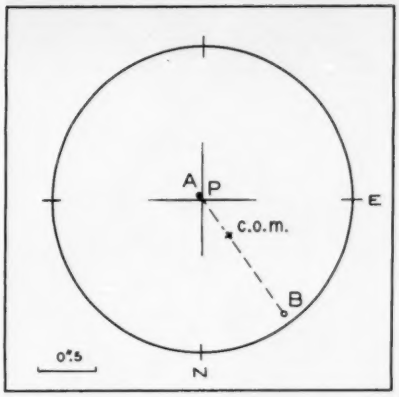


Fig. 3. The positions for March 23, 1955, are shown here. Star B is so faint that on Sproul Observatory plates the image (large circle) of the brighter star always covers the fainter.

centers of the two stars photographed by Dr. Baade were averaged, and the value of 1".2 was adopted for further use. On the Palomar plates the radius of the image of Ross 614A averages 0".9, and the components are not well separated even at greatest elongation. But when a Sproul refractor photograph is exposed long enough to bring out a 15th-magnitude star, the image diameter of Ross 614A grows to 7", which completely envelops the fainter star.

The average size of the Sproul photographic image of Ross 614 is shown by the circle of Fig. 3, where P, A, and B represent the photocenter and the centers of the A and B components, respectively. Star B is so faint that the image of the photocenter always appears circular. The star positions are shown for March 23, 1955, when they were measured as 1".2 apart on Palomar photographs. From the photocentric orbit, we know that the distance of the photocenter to the center of mass was then 0".37. The ratio of these two numbers, 3.2, is therefore the ratio of the scales of the relative to the photocentric orbits. Applying this scale factor to the photocentric semimajor axis, known to be 1.22 astronomical units, we find the relative orbit of the system to have a semimajor axis of 3.9 astronomical units. The Ross 614 system would fit quite easily within the orbit of Jupiter. From the relative orbit and the period, the sum of the masses of the two components comes out as 0.22 that of the sun.

How can we find the individual masses of the two stars? We must make use of the magnitude difference and the distance between A and B found by Dr. Baade. Since the B component is 3½ magnitudes fainter than the primary, it can be calculated that the resulting photographic image on the Sproul plates has been pulled from the A toward the B component by 1/25 of their total separation. We can now relate the distances of the stars and the photocenter to the center of mass. Adopting the relative orbit scale as a unit, we find 0.35 and 0.65 for the scales of the orbits of A and B, respectively, around the center of mass which is their common focus (Fig. 4).

The ratio of the distances of the A and B positions to the center of mass is inversely proportional to their masses, and we already know that the total mass is 0.22 that of the sun. The mass of Ross 614A is 0.14 sun, that of Ross 614B 0.08 sun. The latter has by far the smallest mass yet found for a visible star, and even Ross 614A is less massive than Krueger 60B, which was previously the star of smallest known mass, 0.16 sun. Ross 614B has only half this value.

Evidently Ross 614B is a star, not a planet. Although its visual luminosity is only 1/63,000 of the sun's, it would appear much fainter if it were shining only by reflected light from its primary. Although only 1/12 the sun's mass, it is still 80 times as massive as Jupiter, the greatest planet. The information concerning Ross 614 yields a substantial extension of the mass-luminosity relation for stars of low mass.

A number of other unseen companions await visual detection. In some cases they may remain unresolved photographically, because even their widest separations may be well under a second of arc, and the difference in magnitude may be large. Visually, however, the largest telescopes can split double stars whose components are only a tenth of a second of arc apart, if the magnitude difference is not too great. The Sproul program will allow other predictions of the most favorable times for visual detection, when attempts can be made to see and photograph the unseen companions with very large telescopes, as was done for Ross 614. This approach provides a valuable way to extend our knowledge of the faint stellar population in the vicinity of the sun.

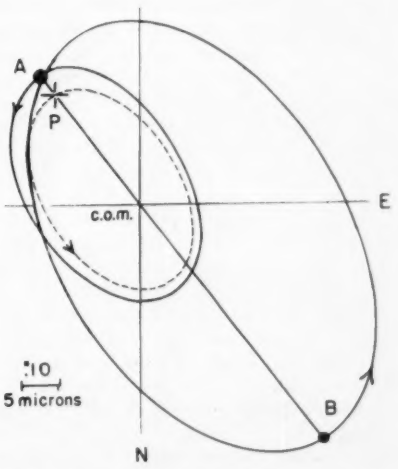
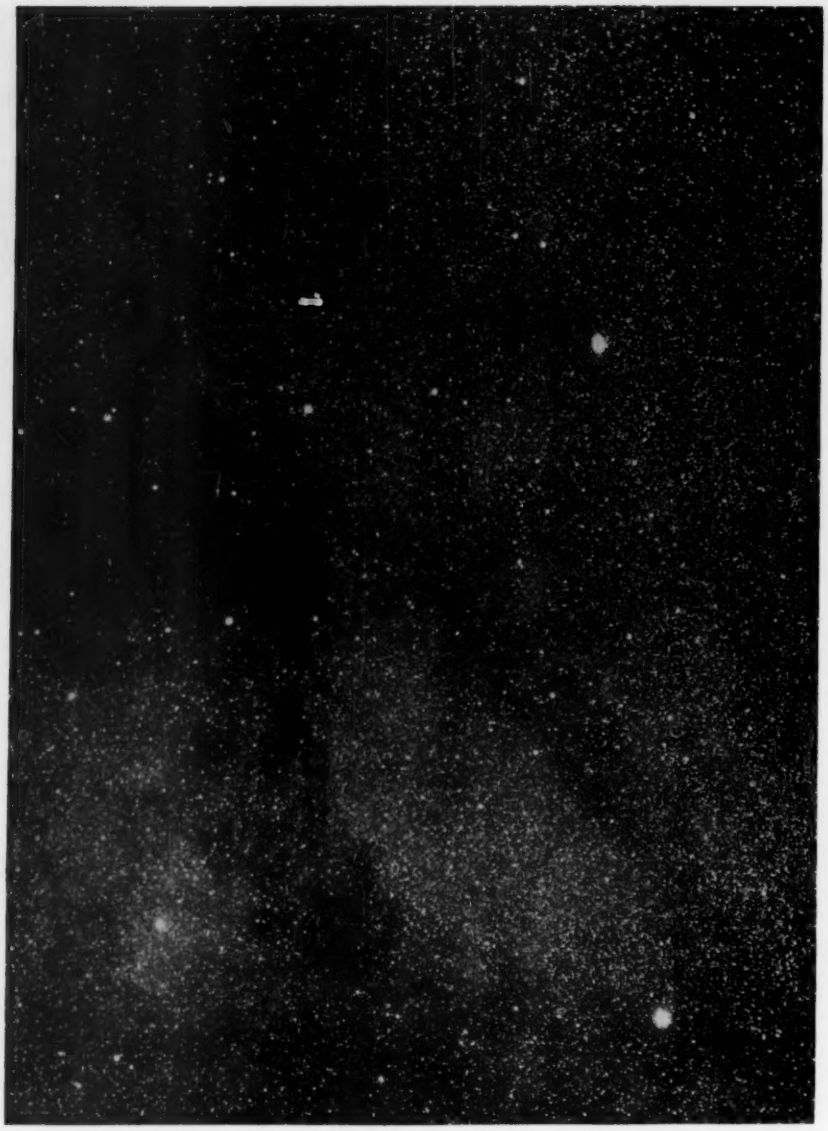


Fig. 4. The dashed ellipse is the orbit of the photocenter, P. The positions of A, B, and P are shown for the discovery date of March 23, 1955.



More on Globular Clusters

OTTO STRUVE

Leuschner Observatory
University of California

Six globular clusters may be identified in this region of the Milky Way in southeastern Ophiuchus, not far from the direction of the galactic center. The two brightest are M62 and M19, in the lower and upper right, respectively. Near the upper edge, right of center, is NGC 6284. In the lower left is NGC 6304, with 6316 above and to its left just below the dark nebulosity, and 6293 above the right edge of the nebulosity. This field, from a portion of Plate 18 of Barnard's Milky Way atlas, may be identified in the key chart on page 396; it also appears in the full-page picture on page 397.

MANY YEARS AGO, when Harlow Shapley determined the distances of globular clusters, his basic method depended upon the short-period variable stars that many clusters contain. An example of this method was given for M13 in Hercules in our discussion of globular clusters and their history last month.

Other information was necessary, however, for those clusters in which no variable stars had been observed. Shapley was able to show that the brightest nonvariable stars of all globulars are nearly alike. Hence, the apparent magnitudes of these stars could be used to determine the distances of their respective clusters. For very distant clusters, in which it was impossible to measure individual star brightnesses, he used integrated apparent brightnesses and angular diameters as distance criteria.

In recent years, it has become necessary to correct the cluster distances originally found by Shapley. When he did his work, the importance of the dimming of starlight by interstellar absorption was not yet realized. New and better observations of the variable stars, of the magnitudes of the brightest stars, of the cluster diameters and brightnesses, have been obtained. The diagram shows the distribution of the presently known clusters upon the plane of the Milky Way, based on revised distances determined in 1952 by W. Lohmann at the University of Heidelberg.

The arrangement of the dots does not differ much from that obtained by Shapley 25 years ago, but the clusters are more symmetrically located with respect to the center of the galaxy and the entire diagram is much more compressed. Shapley had obtained 16,000 parsecs for the distance to the center of distribution of the clusters, while we now find it to be only half as far away. The center distance of 8,000 parsecs in this diagram is slightly smaller than that used in our article last month, and it is preferred by many astronomers.

Of course, most of the clusters are not actually in the plane of the Milky Way (plane of the paper), but are either above or below it. For example, the cluster that overlaps the circle representing the sun is NGC 288 in Sculptor, located close to the south galactic pole but 13,200 parsecs below the plane of the galaxy, according to Lohmann. Because of our failure to discover very distant clusters hidden by obscuring clouds in the sun's vicinity, we do not consider it physically significant that there are more clusters in the region between the sun and the galactic center than there are between the center and the boundary of the galaxy opposite to the sun.

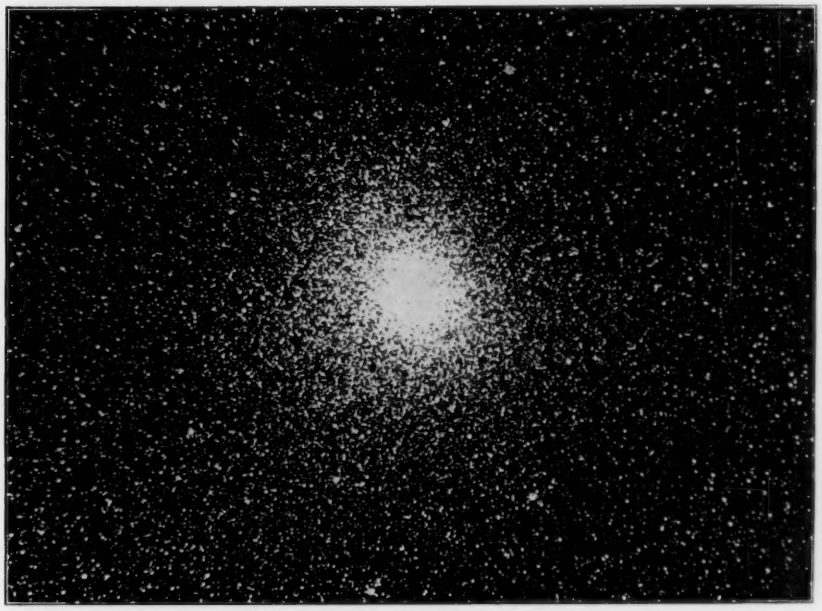
The individual clusters differ strikingly in integrated absolute magnitude (or total luminosity) and in the degree of their central condensation, as illustrated by some of the photographs with this article. The distribution of the absolute magnitudes, graphed here, includes Omega Centauri and 47 Tucanae near

−9, nearly a million times as luminous as the sun. These two objects resemble small galaxies in luminosity and in the number of individual stars. At the other end of the sequence are clusters with absolute magnitudes near −5; although containing a few thousand stars each, the total light of one of these clusters is no greater than that of a single supergiant star in the Milky Way.

The average integrated absolute magnitude of a globular cluster is about −7, while that of the sun is +5.5. This difference of 12½ magnitudes corresponds to 100,000 times in luminosity; we may say that an average cluster contains about 100,000 average (solar-type) stars. The average radius of a globular cluster is about 40 parsecs, and the average density would be about one star for each two cubic parsecs.

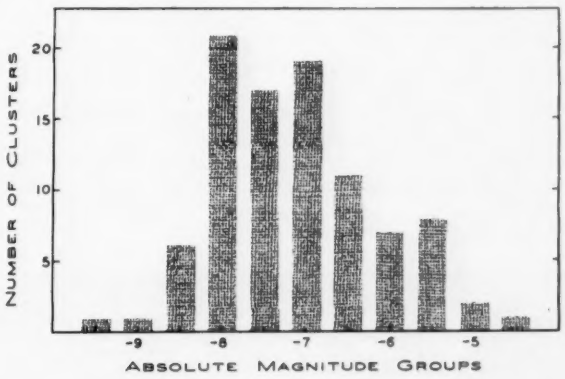
Star counts have shown that for many clusters the density decreases about as the cube of the distance from the center. Thus, near the center of the cluster the density of stars may well be 100 times greater than the average. A density of 50 stars per cubic parsec far exceeds that in the neighborhood of our sun, where it is less than one star per 10 cubic parsecs. Shapley has even remarked that the average distance between cluster stars may be of the order of planetary distances.

This may, however, be somewhat of an exaggeration. Even if we assumed an extreme central star density of 500 stars per cubic parsec, this would be only 5,000 times the density in the sun's neighborhood, where the average distance between stars is about two parsecs. In the extreme globular cluster case, this distance would be about 1/20 as great, or about 20,000 astronomical units. The brightest stars would appear about as luminous as our moon, and the sky from inside the cluster would indeed sparkle with stars; even the faintest cluster members would be easily seen with the naked eye.

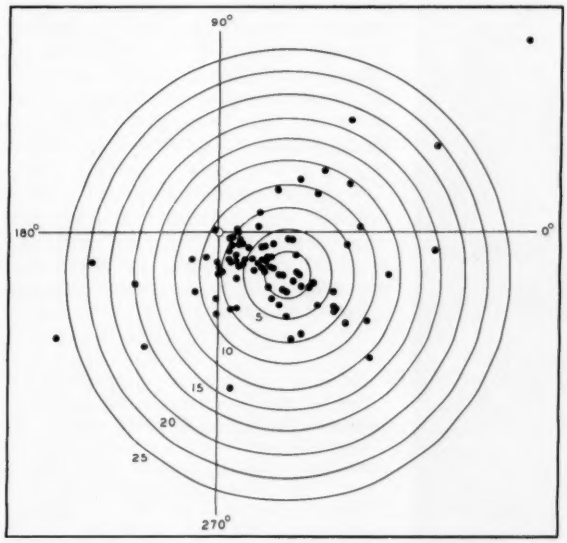


One of the brightest of globular clusters, M22, in Sagittarius. It is typical of a cluster with a heavy concentration of stars toward its center. Mount Wilson and Palomar Observatories photograph.

We should expect that the more luminous clusters are also actually larger than the less luminous ones. That this is indeed the case was shown by Shapley. His diagram showed a general correlation between the size and brightness of 23 globular clusters. In addition, we should expect that the effect of interstellar absorption would be to reduce the apparent angular diameter and consequently also the computed linear diameters. The Russian astronomers P. P. Parenago, B. V. Kukarkin, and N. F. Florja published a discussion of this effect in 1949, and it was confirmed in 1953 by Lohmann.



The globular clusters have been grouped here according to their intrinsic luminosities, from data by W. Lohmann. The absolute magnitude groups are minus 9.75 to 9.25, 9.25 to 8.75, 8.75 to 8.25, and so forth.



A plot of the distribution of globular clusters projected on the central plane of the Milky Way (as if seen from the north galactic pole). The sun is at the center of the cross arms, which are labeled for galactic longitude. The circles represent successive distances of 2,500 parsecs from the galactic center, with those for every five kiloparsecs labeled. Leuschner Observatory diagram.

But in 1952 R. Kurth, of Berne, detected another relation: The linear diameters of globular clusters tend at first to decrease at greater distances from the sun and then they increase again when the distance equals about 25,000 parsecs. This peculiar relation is the subject of a new study by Lohmann (*Zeitschrift fuer Astrophysik, 32,* 248, 1953).

He finds that the linear diameter is really correlated with the cluster's distance from the galactic center and not with its

Globular clusters tend markedly to be larger, the more distant they are from the galactic center. Adapted from W. Lohmann's 1953 paper in the "Zeitschrift fuer Astrophysik."

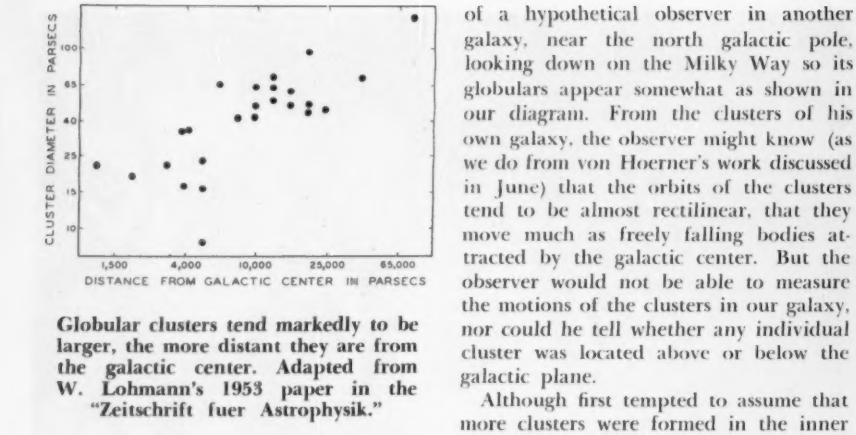
distance from the sun. His diagram shows that those clusters 25,000 parsecs from the center are about 30 per cent larger than those at only 10,000 parsecs. This suggests an important cosmogonical effect: Those clusters that were formed near the outer boundaries of the original galactic cloud were considerably larger than those born in the vicinity of the center.

The clusters near the center, however, are a mixture of those actually born near the center and others whose orbital motions have carried them inward. Can we infer from the present distribution, illustrated on page 367, how far from the galactic center the clusters were *first* formed?

The concentric circles divide the diagram into a number of rings, and counts of the numbers of clusters in these are shown in column 2 of the table. If we divide each number by the area of its ring, we obtain the number of clusters per unit area in the galactic plane. These values (in column 3) show an even higher concentration to the center than those in column 2.

Let us place ourselves in the position of a hypothetical observer in another galaxy, near the north galactic pole, looking down on the Milky Way so its globulars appear somewhat as shown in our diagram. From the clusters of his own galaxy, the observer might know (as we do from von Hoerner's work discussed in June) that the orbits of the clusters tend to be almost rectilinear, that they move much as freely falling bodies attracted by the galactic center. But the observer would not be able to measure the motions of the clusters in our galaxy, nor could he tell whether any individual cluster was located above or below the galactic plane.

Although first tempted to assume that more clusters were formed in the inner regions of the Milky Way than in the outer regions, the hypothetical observer would soon consider the shortness of the orbital periods—a few hundred million years compared to a galaxy's lifetime of several billion. He would also recall that the clusters would spend most of their time near their apogalacticon points, as we learned last month. With the help of Kepler's laws, he would quickly calculate the probability of finding any given cluster at 1/10 its apogalacticon distance from the center, at 2/10, 3/10, and so on. Each cluster would be much more likely to be found at its greatest distance from the center than anywhere else along its straight orbit. But as all clusters tend to approach the galactic center, the probability that a considerable fraction of them would be in its vicinity should be quite appreciable. Moreover, the projection onto the galactic plane has further exaggerated the apparent concentration toward the center.

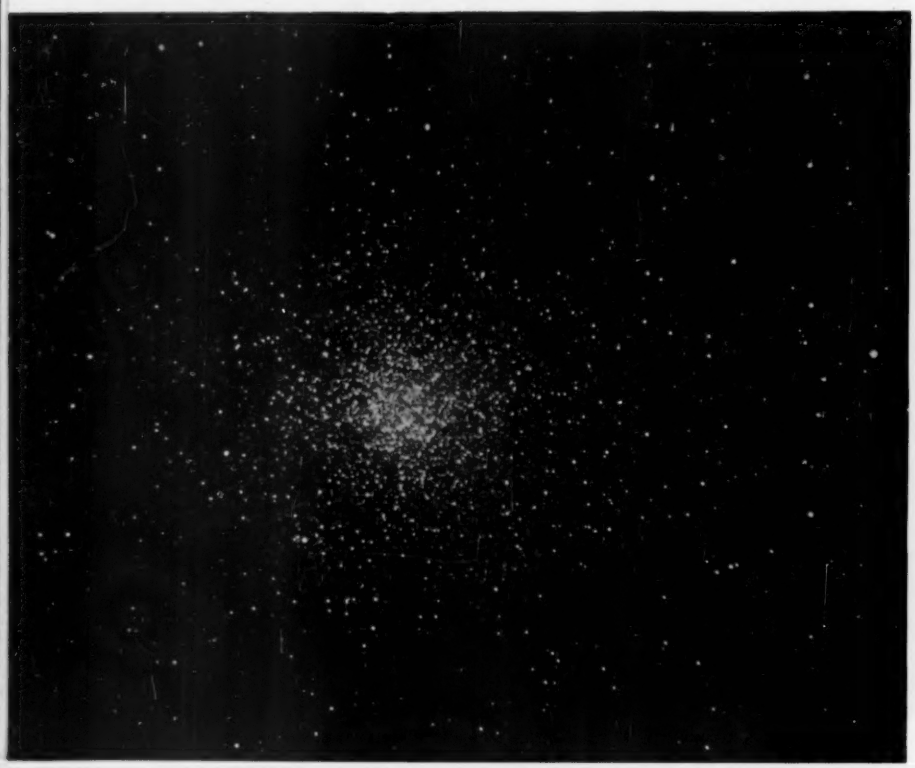


A globular cluster, NGC 3201, that has scores of variable stars and a low central concentration. It is located in the constellation of Vela. Harvard Observatory photograph.

DISTRIBUTION OF GLOBULAR CLUSTERS

1 *Ring limits*	2 *Observed number in ring*	3 *Observed areal density*	4 *Computed number in ring*	5 *Computed areal density*	6 *Original distrib. in shells*	7 *Original volume density*
0 – 2½	12	61.2	3	14.4	0	0.0
2½ – 5	20	34.0	6	10.0	11	42.7
5 – 7½	27	27.5	7	7.5	25	35.8
7½ – 10	14	10.2	8	6.1	23	16.9
10 – 12½	7	4.0	10	5.3	16	7.1
12½ – 15	2	0.9	10	4.7	2	0.6
15 – 17½	2	0.8	11	4.3	0	0.0
17½ – 20	2	0.7	11	3.8	1	0.2
20 – 22½	2	0.6	12	3.5	4	0.5
22½ – 25	1	0.3	11	3.0	7	0.7

The ring limits are given in kiloparsecs (one kiloparsec equals 1,000 parsecs), and areal densities are in number of clusters per 100 square kiloparsecs in the galactic plane. The volume density is the number of clusters per 1,000 cubic kiloparsecs.



One of the nearest of the globular clusters, M55, NGC 6809, which is noted for its loosely packed structure and for a lack of variable stars. Harvard Observatory photograph with the 60-inch reflector of the Boyden station.

On the basis of an origin of the Milky Way and the clusters from a spherical cloud of turbulent gas and dust, the astronomer in the distant galaxy might adopt the working hypothesis that all our globulars were formed from relatively dense knots of diffuse matter arranged in a thin spherical shell at a distance of 25,000 parsecs from the center. Birth of the clusters would take place during perhaps a billion years.

He would next compute the time for each cluster to travel from the ring of its origin to one of the other rings. This would enable him to estimate how many clusters would be located in each spherical shell. He would then compute the number of clusters seen in projection on the plane of the Milky Way in each ring; a cluster 20,000 parsecs from the center might be seen in the diagram on one of the inner rings. In this way, he would predict the values in columns 4 and 5 of the table. We notice that these numbers indicate much less pronounced concentration toward the center than do the direct counts of columns 2 and 3. Because of this disagreement with the observed concentration, he would conclude that the clusters were not all produced in the outermost shell at a distance of 25,000 parsecs.

The distant observer would next carry out a new series of calculations, assuming that the probability of a cluster being born in a shell was proportional to the shell's volume. This would mean that a cluster whose present distance is 10,000 parsecs could have been born there, now being at its apogalacticon, or it could have been born in any one of the outer shells and now be either on its way toward the center or away from it.

This assumption of a uniform distribution of the birthplaces of the clusters would tend to increase the computed concentration of the dots toward the center, but not sufficiently to account for the numbers in columns 2 and 3.

Hence, it is necessary to adjust the numbers of clusters born in the various shells in such a manner as to represent the observed distribution. These numbers are shown in column 6 of the table, and the corresponding volume densities of the places of birth in column 7. On this model, very few if any clusters were born in the immediate vicinity of the galactic center, and an appreciable number were formed at greater distances—up to about the outer limits of the original cloud at 25,000 parsecs. The central region is believed instead to have favored the condensation of a large number of stars that now form the central bulge of the Milky Way.

The foregoing thoughts fit well with von Weizsaecker's theory of the origin of the Milky Way and the globular clusters (June issue, page 328). I have been assisted by C. B. Stephenson and G. W. Preston in carrying out the computations involved in this discussion.

Amateur Astronomers

Charlie M. Noble Planetarium Dedicated

IN APRIL, the Fort Worth Children's Museum opened its new planetarium, a permanent installation named for Miss Charlie M. Noble, a longtime teacher of astronomy and sponsor of astronomical activities among juniors in Ft. Worth.

The planetarium projector is a Spitz Model A, which may be controlled from a speaker's booth in the west wall of the chamber. A high-fidelity sound system, circular red-leather upholstered seats, and a silhouetted skyline of the city are other features of the installation. The skyline was prepared by Norman Cole, and he also built a solar system black-light exhibit in the corridor outside of the chamber. The projector and appointments of the planetarium chamber are the gift of Mr. and Mrs. Kenneth W. Davis. William G. Hassler, executive director of the museum, designed the chamber and supervised the construction. Elsewhere in the museum building design, astronomical motifs are featured.

The first Spitz projector in Ft. Worth was purchased by the Junior League and installed in a tent on the old museum grounds on Summit Avenue. Miss Noble was teaching the museum astronomy classes at the time, and during the following two years more than 25,000 visitors and students enjoyed the stars under her tutelage, in the "small theater in a tent."

The new planetarium gives free lectures for school classes and public lectures at admission fees of 50 cents for adults, 25 cents for children. Information may be obtained from the Fort Worth Children's Museum, 1501 Montgomery St., Ft. Worth, Tex., telephone PA-1461.

CORRESPONDENCE AMONG GREAT PLAINS AMATEURS

I became interested in astronomy some three years ago. For a long time I sought in vain for other amateurs in this area or an organization I might join. Replies to my letters stated, "We know of no organizations in your area." It is no surprise that I felt quite alone with my telescope.

With such activity in the rest of the country, I could not believe I was the only enthusiast in a region including most of Nebraska, Iowa, South Dakota, and Kansas. I found the names of two amateurs, each of whom could suggest one or two more. The list has grown in this way until now, two months after its commencement, it contains the names of over 40 persons. No doubt there are many others to be found.

This list, as well as one with places of astronomical interest, has been sent to the amateurs in the area so they might contact each other, and perhaps plan observations of phenomena from widely scattered points. When fireballs occur, the list will enable an investigator to obtain reports without delay.

With distances as great as they are between us, meetings of the loosely knit group will probably be few, if any. However, the opportunity to get in touch with others in the area will improve observing and stimulate interest.

Other amateurs in this four-state area are invited to send their names and addresses to me.

GEORGE EAGLETON
1422 L St.
Tekamah, Nebr.

CRANBROOK PLANETARIUM

A new wing to house a Spitz Planetarium is being constructed at the Cranbrook Institute of Science, Bloomfield Hills, Mich. This will be Michigan's first public planetarium, and it is being built with the aid of publicly subscribed funds. The architect, W. E. Kapp, has contributed his services.

The 79-seat chamber will be 30 feet in diameter and 23 feet high. The dome will be of sprayed concrete on a light structural-steel framework; the interior will be lined with high-reflection acoustic plaster.

The Cranbrook Institute celebrates its 25th birthday this summer, and hopes to have the planetarium completed by then.

THIS MONTH'S MEETINGS

Chicago, Ill.: Burnham Astronomical Society and Chicago Astronomical Society. July 23, 8 p.m., 15th annual observation party, home of Mr. and Mrs. H. C. Torreyson, 13 E. Palatine Rd., Prospect Heights.

Kalamazoo, Mich.: Kalamazoo Amateur Astronomical Association, 8 p.m., home of Mr. and Mrs. Fred Mantele, 132 Big Rock Rd. July 16, Dr. James O. Lawrence, "Radio Stars"; Vernell R. Shellman, "Photography in Astronomy."

AKRON SOCIETY LAPEL PIN

Last fall the Astronomy Club of Akron, Ohio, adopted the gold-on-black lapel pin pictured above. The design, by Robert J. Couts, was selected from original drawings by members. The nominal cost of the pin is covered by the society initiation fee.

AMERICAN ASTRONOMERS REPORT

Here are highlights of some papers presented at the 92nd meeting of the American Astronomical Society at Princeton, N. J., in April. Complete abstracts will appear in the Astronomical Journal.

44i Bootis

The fainter component of the well-known visual binary 44i Bootis is itself double—an eclipsing binary of the W Ursae Majoris type with a period of 6½ hours and a light range of 0.4 magnitude. Dr. L. Binnendijk, of Cook Observatory, has made extensive photoelectric observations of this variable in yellow light, at Goodsell Observatory in 1953 and at Cook in 1954. Since the separation of the visual pair was only 1.2 seconds, his measurements include the light of the brighter visual component, as do all other recent photometric studies of the variable. This circumstance reduced the light range, as actually observed, to under 0.2 magnitude.

Comparison of the new light curve with earlier ones shows marked differences from year to year. Of the two maxima that occur in each cycle, that following primary minimum was the lower in 1930, but in 1953-54 it was actually the higher, by a narrow margin. Furthermore, the hump during the rise after secondary minimum that can be seen in the 1935 and 1947 curves is now practically absent.

Dr. Binnendijk has computed the dimensions and masses of the two members of the eclipsing system, by combining with his data the spectrographic observations of D. M. Popper. The larger star matches the sun in diameter and mass, while the other has 0.6 the size and half the mass. Two such stars revolving nearly in contact form a system near the limits of dynamical stability, Dr. Binnendijk points out. This conclusion is in accord with the alterations in the shape of the light curve and the observed changes in the period of light variation.

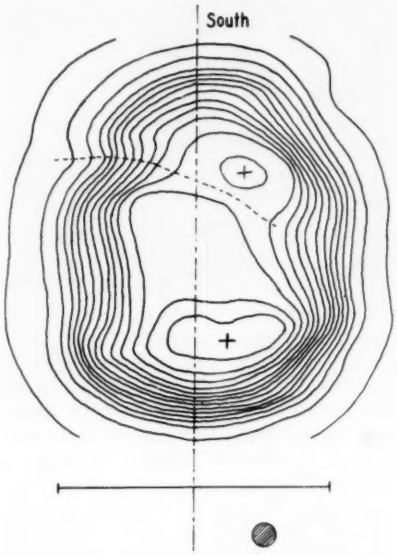
Photoelectric Mapping of Mars

A method for measuring the brightness of different portions of the disk of Mars was tried in 1954 by Roger Hosfeld, of Ohio State University. He used the 12½-inch McMillin Observatory refractor, in whose focal plane the planet's image was 1/50 inch across. As this image drifted over a pinhole less than 1/10 its diameter, the light transmitted by the hole was recorded by an RCA 6199 phototube and a Brush direct-inking oscillograph.

From 10 such sweeps at different Martian latitudes, each repeated three times, a brightness-contour map of the planet was constructed. Even though a yellow filter was used to sharpen the image of the visually corrected refractor, the contours extend somewhat beyond the geometrical limits of the planet's disk, primarily due to unsteady seeing. Nevertheless, the grosser features on the disk are recognizable.

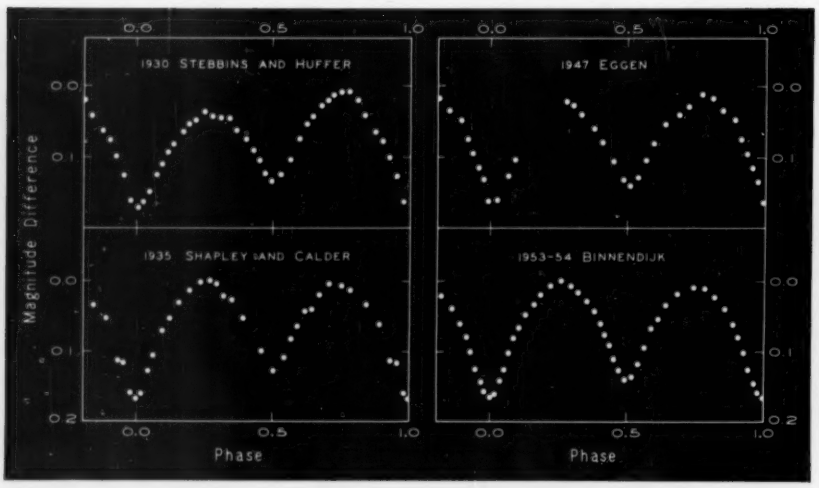
The actual diameter of Mars is indicated by the straight line below the map itself. The two brightest portions of the planet, marked with crosses, are the south polar cap, above, and Elysium. The dashed line, where a dark trough cuts across the pattern, corresponds to the planet's girdle of dark "seas."

Mr. Hosfeld pointed out that if this measure of success can be attained with a small telescope, then large reflectors, located where the seeing is good, should be capable of making valuable photoelectric intensity and color measurements on both the permanent and transitory features of the Martian disk. Such work would aid studies of the planet's atmosphere and the nature of its surface.



PHOTOELECTRIC ISOPHOTES OF MARS

A photoelectric contour map of Mars, obtained experimentally by R. Hosfeld with the 12½-inch McMillin refractor on June 28-29, 1954. At the midpoint of the observations, which required half an hour to complete, the Martian longitude of the disk's center was 217°. The area of the aperture for each scan is shown by the small shaded circle at the lower right.



Changes in the mean light curve of 44i Bootis are shown here according to the work of different investigators. In constructing this chart, Dr. Binnendijk has adjusted the zero points of the magnitude differences to give the best agreement with his own light curve, but has not altered the magnitude scales of the original photoelectric curves.

Radio Map of the Winter Sky

Drs. H. C. Ko and J. D. Kraus, Ohio State University, have prepared a radio map of the winter Milky Way, from observations with the 96-helix antenna of the Ohio State radio telescope, operating at a wave length of approximately 125 centimeters. Their corresponding map for other parts of the Milky Way was reproduced in the November, 1954, *Sky and Telescope*, pages 22-23. The new map is both more accurate and more detailed. The contour interval corresponds to an equivalent temperature difference of about seven degrees (about one third the interval on the older map). Moreover, distortions of the contours due to the antenna pattern are now removed.

The contours on the map indicate the

relative brightness of the cosmic radio background, while dots and circles show a number of the intense radio sources in the region. The "magnitudes" of the sources, which are analogous to stellar magnitudes, are based on the assumption that the Crab nebula in Taurus (05N2A) is of the 1st magnitude. It is the strongest localized source on the map, while the H-II emission region in Orion is the strongest extended source.

The Rosette nebula in Monoceros, which surrounds the galactic cluster NGC 2244, was found to be a 3rd-magnitude radio source with a diameter of about $1\frac{1}{2}$ degrees.

A new 5th-magnitude scintillating source was discovered at right ascension $8^h\ 20^m$, declination $+8°$. Although scintillations (similar to optical twinkling of stars) are commonly observed at longer radio wave lengths, this is the first time the effect has been noted at 125 centimeters. One possible explanation is that this source is actually of stellar dimensions, and not a large nebulosity. Attempts to identify it with an optically observable object have not been successful.

The winter sky is of particular interest because it contains the region of the galactic anticenter, near $5^h\ 40^m$, $+28°$. The ridge line on the map is slightly south of the galactic equator, but its point of minimum intensity is quite distant from the anticenter.

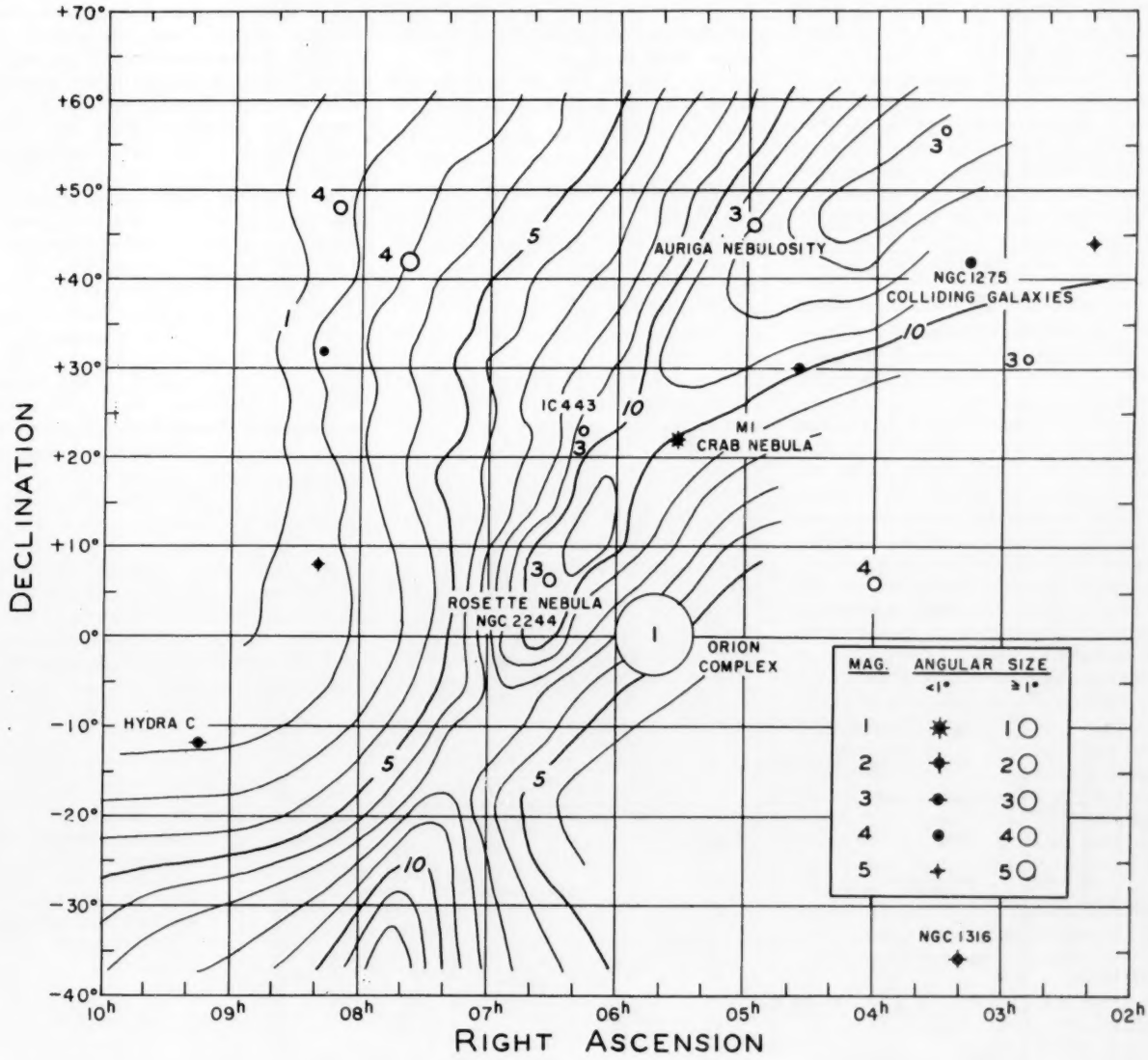
200-inch Studies of the Andromeda Nebula

At Palomar Observatory, the nearby spiral galaxy, M31 in Andromeda, has been the subject of searching investigation with the Hale telescope. Three papers by Dr. W. Baade, one jointly with Henrietta H. Swope, report some results of this study.

One of the first major programs planned for the 200-inch telescope was a reinvestigation of M31 for variable stars. With its f/3.67 correcting lens, which provides a field of fine definition 16 minutes of arc in diameter, the Hale telescope has proved to be a most efficient instrument for this type of work. Three fields were intensively observed during 1950-51 on 103a-O plates of 30 minutes exposure, limiting photographic magnitude 22.8. Altogether 711 variables were found. Light curves in two fields have been derived by Miss Swope, and for the third field by Dr. S. Gaposchkin, Harvard Observatory.

Dr. Baade's paper on this program was given jointly with Miss Swope, concerning two of the fields.

There are 275 Cepheid variables, 38 of them in Field I, 15 minutes south preceding the nucleus of the galaxy; 237 of them in Field III, 50 minutes south



In this Ohio State University radio map of part of the Milky Way, the contour intervals are labeled with italic numbers.

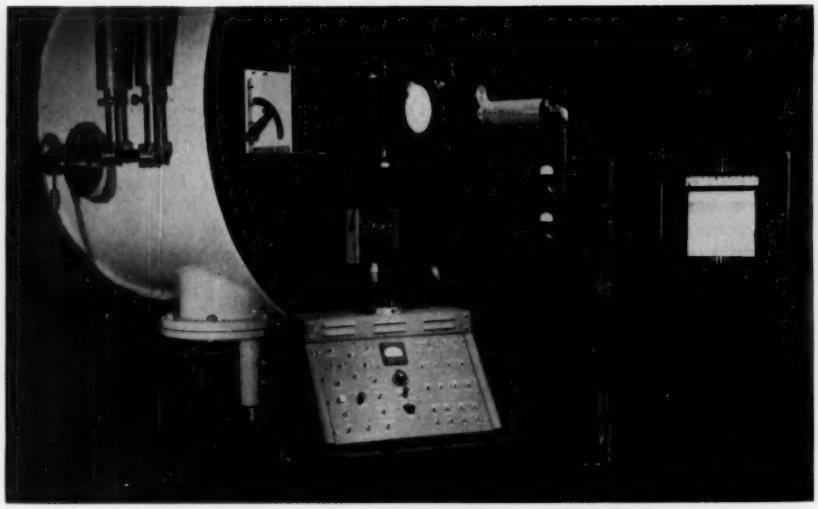
preceding the nucleus. Thus, the Cepheids are strongly concentrated in the spiral arms. The shortest period observed is just under three days. In Field III, some variables may be more than 1½ magnitudes fainter than others—clearly the effect of light absorption by dust in the spiral arm there.

The brightnesses of the least obscured Cepheids gives a distance modulus of 24.25 magnitudes, corresponding to a distance of about two million light-years for M31. This is farther than Dr. Baade had announced in 1952 at Rome; the difference is due to improvement in the magnitude scale for stars in the Andromeda nebula, which is now based on photoelectric standards.

Experience has shown that under good seeing conditions photovisual magnitude 23.0 can be reached with the 200-inch telescope in exposures of 60 to 80 minutes. Since this corresponds to absolute magnitude −1.25, there seemed to be a good chance that at least the brightest planetary nebulae in this galaxy would be observable. Dr. Baade's second paper reported the discovery of five such objects in a field 96 minutes south preceding the center of M31. Planetaries so remote do not show appreciable disks, but most of their light comes from emission lines in the green part of the spectrum. Therefore, they are recognizable from comparison of green photographs, on which planetaries appear bright, with red photographs, on which they are much fainter.

The new planetaries are 22nd-magnitude objects, with corresponding absolute magnitudes of −2.1, in good agreement with L. Berman's result for planetaries inside our own galaxy.

In his third contribution, at the symposium on relations between gas, dust, and stars, Dr. Baade pointed out that dust in M31 is localized in the spiral arms, for the globular clusters in the arms are redder than those outside. The presence of interstellar gas in the spiral arms is proven by the observation of H-II regions of ionized hydrogen surrounding hot stars. Photographs of M31 with the Hale telescope show evolutionary development as a spiral arm is traced outward: In the inner part of an arm is found dust, but not the hot, blue *B* stars that are believed born from dust clouds; farther along the arm are found *B* stars and H-II regions; and the outer reaches of the arm are marked by *B* stars but contain no dust.



The observing room of the McMath-Hulbert vacuum spectrograph.

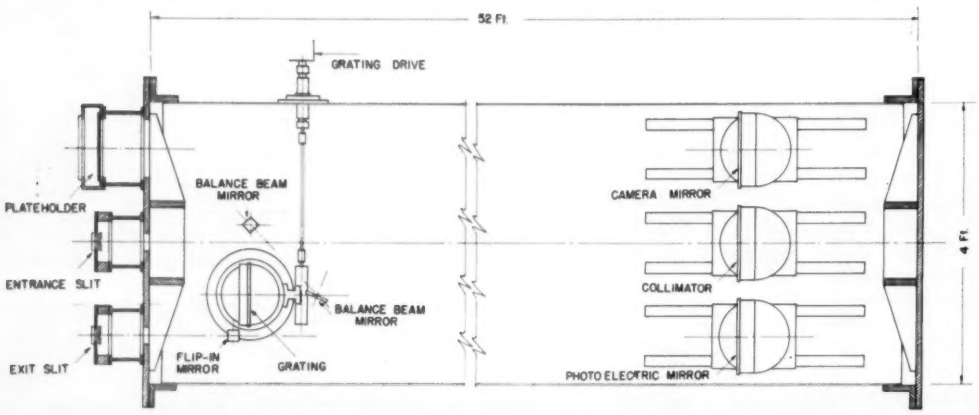
McMath-Hulbert Spectrograph

A report on the 52-foot vacuum spectrograph of the McMath-Hulbert Observatory, University of Michigan, was made by Dr. Robert R. McMath in his address as retiring president of the American Astronomical Society. Some details of the apparatus were given on page 372 of *Sky and Telescope* for September, 1954.

The purpose of the new spectrograph is to measure the profiles of faint as well as strong dark lines in the solar spectrum, a major need in present-day studies of the sun. In order to obtain full performance of the practically perfect Babcock grating, the spectrograph is designed especially to reduce scattered light, and the tube of the instrument, 52 feet long and four feet in diameter, is evacuated to eliminate convection currents and consequent bad seeing in the optical path.

Initial tests indicate that the performance of the spectroscope is good. The tube can be evacuated to the limiting pressure of the pump, 30 microns or 1/25,000 of an atmosphere. In the region of the K line of calcium, in the seventh-order spectrum, the dispersion is 11 millimeters per angstrom. With this enormous dispersion, the solar lines are so broad and diffuse that, to test for focus, it is necessary to superimpose a laboratory spectrum that has numerous very narrow lines, such as that of iodine shown here. The resolving power is 600,000.

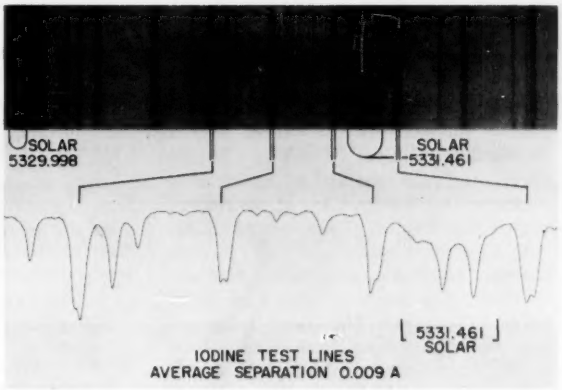
The photograph of the observing room shows a bright round image of the sun falling upon the first or entrance slit in the middle of the tube's end plate. This image has been formed by the 50-foot McGregor solar tower. Light passes from this entrance slit to the collimator at the other end of the tube, as the diagram indicates. Then it returns to the grating near the front end of the tube, back to the photoelectric mirror and out the exit slit. The photoelectric cell may be seen to the right of the entrance slit in the photograph, connected by wires to the panel containing the amplifiers. The recorder is to the right of the amplifiers, and the control panel is in the center foreground.



This diagram shows the arrangement of the apparatus in the 52-foot tube of the McMath-Hulbert vacuum spectrograph.

As a scan is made by the photoelectric apparatus, the brightness of the sun is monitored by an auxiliary photocell, so that changes in sky transparency can be allowed for in measuring the spectrum tracings.

The spectrum may also be photographed, in which case the camera mirror is used to send light to the plateholder, which is seen attached to the end plate to the left of the entrance slit.



In these superposed spectra of iodine and the sun, the close double lines of iodine have an average separation of 0.009 angstrom, yet are split on the negative by the high resolving power of the Babcock grating. University of Michigan photograph.

Programs envisaged for the vacuum spectrograph include determination of the abundances of elements in the solar atmosphere, from the equivalent widths of their spectral lines; studies of large-scale motions and turbulence on the sun; and measures of kinetic temperature changes with height above the sun's photosphere. When the McMath-Hulbert spectroheliograph shows interesting transient phenomena on the sun, the vacuum spectrograph can be used simultaneously.

Composition of Ellipticals

There is little direct evidence about what kinds of stars make up elliptical galaxies like M32 (the companion to the great Andromeda nebula), for at best only the very brightest stars in them are directly observable. These are similar to the brightest stars in globular clusters, and from this it has been widely assumed that the ellipticals are composed entirely of Population II stars. But indirect evidence that this assumption may not be valid was presented by Dr. W. A. Baum, of Mount Wilson and Palomar Observatories.

He has developed two models in an attempt to fit observations of elliptical galaxies. His "modified Population II" model is made up of stars having the same chemical composition as those in globular clusters but with a much greater representation of dwarf stars (or subdwarfs). His "old Population I" model is made up partly of stars having the same chemical composition as the predominant population in our own galaxy and partly of undisturbed gas. It was assumed that neither model contains stars younger than several billion years.

The color-luminosity diagram for the modified Population II model is identical with that for globular clusters, but the relative numbers of stars along the main sequence is radically different. The main sequences of both models are similar, but stars that have recently evolved from the main sequence in the old Population I model are assumed to live in the normal giant region around absolute magnitude zero, instead of climbing to −3 and lingering afterward along a horizontal branch.

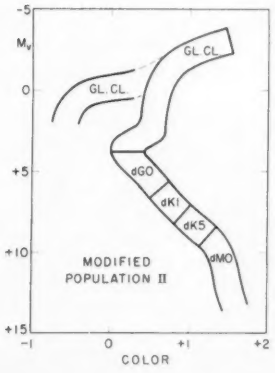
Comparison of the models with the spectral-energy distribution and mass-luminosity ratios for large ellipticals indicates that the old Population I model is the more acceptable of the two. But the predominance of this model in a galaxy would not preclude a minority of ordinary Population II stars, which is consistent with the detection of red giants at absolute magnitude −3 in M32.

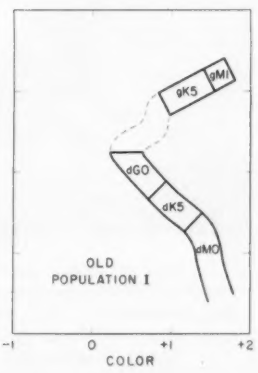
The old Population I model may also explain why very remote elliptical galaxies appear redder than nearer ones. The remoter galaxies are being observed at earlier stages in their evolution, by light that left them hundreds of millions of years ago. Ellipticals may become bluer as they grow older, because their red giant stars are gradually depleted by evolutionary processes.

Radio Sources Detected at 3.15 Centimeters

Last July, at the Naval Research Laboratory, F. T. Haddock and T. P. McCullough carried out a survey of discrete radio sources at a wave length of 3.15 centimeters (frequency, 9,500 megacycles per second). The 50-foot diameter paraboloidal antenna had a pencil beam whose width was about nine minutes of arc, and a chopper-type radiometer with a one-second time constant was used.

Seven sources were detected, and these were the brightest previously observed at 9.4 centimeters. They included the Orion nebula and a source recently suggested as the nucleus of the Milky Way galaxy. This is the first radio detection of galactic or extragalactic radiation at a wave length shorter than 9.4 centimeters.





The color-luminosity diagrams for stars in W. A. Baum's two models of elliptical galaxies. Spectral classes are shown along the sequences; "d" stands for dwarf, "g" for giant stars.

BOYDEN STATION RESEARCH TO CONTINUE

(Continued from page 359)

tion of the station in conjunction with Harvard Observatory.

Under an interim two-year agreement, which may later become permanent, scientific control of the station will rest in an administrative council composed of the directors of the six co-operating observatories. Each member of the council will report concerning finances, appointments, instruments, and programs to the institution he represents at home. Observing time will be shared at the ADH telescope, the 60-inch reflector, and the smaller instruments, and improvements to the 60-inch will be considered to make it more useful for different types of observation.

In recent years, Hamburg and Stockholm have both contributed much to the systematic classification of stellar spectra, Uccle has been a center for asteroid observation, while Armagh has been concerned with galactic research, and Dunsink with photoelectric and spectrographic work. Use of the Boyden station will permit further extension of these activities in the southern sky.

E. M. Lindsay, Armagh
H. A. Brück, Dunsink
O. Heckmann, Hamburg
D. H. Menzel, Harvard
B. Lindblad, Stockholm
P. Bourgeois, Uccle

NEWS NOTES

By Dorrit Hoffleit

SOLAR ECLIPSES SEEN FROM JUPITER

Observers of total eclipses of the sun from Jupiter would not feel as rushed as earth-bound astronomers. For the Galilean satellites, totality at an eclipse might last from 10 minutes to over two hours. In the *Journal* of the British Astronomical Association, B. Peek points out the striking consequences of the fact that the shadows of satellites III and IV cross the disk more slowly than the planet's equatorial velocity of rotation. For either of these satellites three total eclipses normally occur in rapid succession, 12 contacts in all, although contacts 4, 5, 8, and 9 are sometimes lacking. For some favorable latitude the three totalities could run together, giving one long totality lasting 2 hours 44 minutes for an eclipse by satellite III, and 2 hours 24 minutes for one by satellite IV. This is based on a rotation speed close to that of System II.

Mr. Peek suggests that if sunlight tends to inhibit the formation of clouds of ammonia droplets or crystals, it is possible that a white cloud may sometimes form over a locality at which the sun has suffered prolonged eclipse. He suggests that toward the end of a shadow transit of III at latitudes −19° or +19°, where the longest totalities occur, it might be worthwhile to look for a white spot against the dull background of the belt, closely following the shadow. Observers should be warned against a possible spurious effect, resulting from contrast with the black shadow. In the planet's equatorial zone, the effect might be seen closely *preceding* the shadow of III 10 or 20 minutes after middle of transit of the shadow, as seen from the sun, for the shadow will actually be retrograding across Jupiter after 1½ hours of totality.

QUEBEC GEOLOGICAL FEATURE EXPLORED

The Dominion Observatory, at Ottawa, reports results of a survey by Canadian scientists last summer of a huge crater-like feature in Northern Quebec, enclosed by Lakes Manicouagan and Mushalagan. This circular depression, covering 680 square miles, is roughly 150 miles northwest of Seven Islands, on the St. Lawrence.

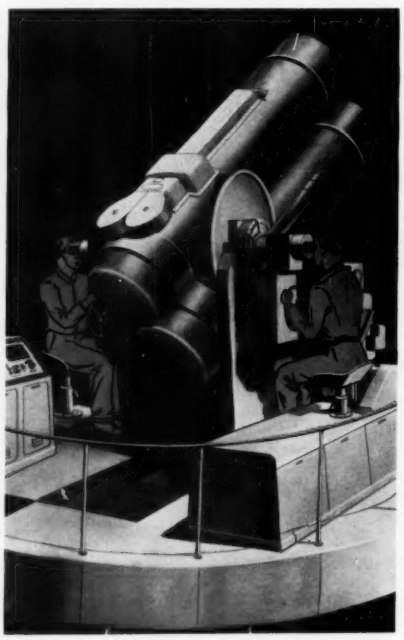
Magnetic, gravity, seismic, and geological observations were made to determine whether or not this formation resulted from the fall of a meteorite many years ago. Although not disproving the theory, the survey provided no positive evidence to support it. Instead, the geological indications are that the region between the lakes suffered igneous intrusion and volcanism, probably in Pre-Cambrian times. The Dominion Observatory's report suggests that, after the central igneous core formed, the depression developed by erosion along faults such as mountain-building forces would produce.

MISSILE TRACKING TELESCOPES

A versatile new two-telescope tracking instrument to be used by the Air Force is being designed by the Perkin-Elmer Corporation for work on long-range guided missiles. It is called ROTI (Recording Optical Tracking Instrument), and will consist of a reflecting telescope and a Schmidt-type instrument carried together on the same mounting.

A fixed-focus telescope can provide accurate positional and other performance data over only a limited range of missile distances. The new telescopes have 16-inch apertures and variable focal lengths, the Newtonian from 100 to 500 inches in steps of 100, the Schmidt from 50 inches to 100 in steps of 25 inches. One telescope will use color, the other black and white, 70-mm. film at frame rates up to 100 per second. Time, altitude and azimuth will also be simultaneously recorded photographically.

One or two operators can track the instrument on the missile, using smaller guide telescopes as shown in the picture. Electronics-assisted tracking will largely compensate for the vagaries of human guiding. The operators can swing the large instruments at a rate of 10 degrees per second in both co-ordinates.



This sketch shows the 16-inch telescopes of the recording optical tracking instrument. It is mounted on a gun turret. Photograph from Perkin-Elmer "Instrument News."

Two ROTI units are to be set up at Holloman Air Force Base in New Mexico, separated by about 50 miles. Synchronized in their operation, they should yield missile positions accurate to 30 seconds of arc or better than nine inches in a mile. The wide-field telescope can record launchings from as close as 1,000 yards, while the Newtonian at 500 inches focal length can see a golf ball eight miles away under relatively poor light conditions.

PRACTICAL USES FOR COSMIC RAYS

Practical uses have been found for cosmic rays. In New South Wales, Australia, engineers on the Snowy Mountains hydroelectric project are enlisting the rays to tell the density of the land mass above a tunnel, without recourse to the usual time-consuming drillings and samplings. Geiger counters at various points within the tunnel record the intensity of cosmic radiation. A comparison with similar records obtained outside will reveal the density of the strata above the tunnel.

The second use is in navigation and surveying. For this, U. S. Patent No. 2,706,793 has been granted to L. W. Alvarez, University of California, B. Rossi, Massachusetts Institute of Technology, and F. C. Chromey, of the du Pont Company. Their device is a V-shaped array of three Geiger counters, forming a cosmic ray telescope with which the direction of the zenith can be accurately found. When the cosmic ray intensity coming down one

IN THE CURRENT JOURNALS

THE SPIRAL STRUCTURE OF THE GALAXY, by W. W. Morgan, *Scientific American*, May, 1955. "Thirty years ago the great U. S. astronomer George Ellery Hale published a small book outlining the picture of our galaxy, the Milky Way, as it looked to astronomers at that time . . . . Today we have a very different picture of our galaxy, which illustrates in a dramatic way the great advances in astronomy that have taken place within a single generation."

METEORITES LARGE AND SMALL, by John F. Heard, *Journal*, Royal Astronomical Society of Canada, March-April, 1955. "If these presently-favoured views are correct we have then, descending upon the earth, fragments of planets and of comets and, as well, samples of the material from which these bodies were originally formed."

GLIMPSES OF THE HUMAN SIDE OF SIR ISAAC NEWTON, by Henry P. Macomber, *Scientific Monthly*, May, 1955. "There is a feeling that he was a monument of ascetic austerity—a notion that I hope to contradict with these less familiar glimpses of the human side of Newton."

arm of the V matches that coming down the other, the axis of the V is vertical. While it has been known since 1934 that the direction of maximum cosmic ray intensity is displaced westward from the zenith, this east-west effect is compensated for in the new Navy-sponsored invention, which can be used to find the vertical on an airplane in flight.

COMET ABELL

On April 13, 1955, a new 15th-magnitude comet was discovered in Canes Venatici, by G. O. Abell on Sky Survey plates taken with the 48-inch Schmidt telescope at Mount Palomar. A preliminary orbit calculation has been made by Dr. L. E. Cunningham, Leuschner Observatory, on the basis of positions on April 15, 17, and 23. The orbit is of very high eccentricity, and a parabolic solution leaves very small residuals from the observed positions.

The remarkable feature of this comet is its great perihelion distance, 5.05 astronomical units, so that when Comet Abell (1955b) was closest to the sun, on June 19, 1954, it was just within the orbit of Jupiter.

U. S. GOVERNMENT OPPOSES CALENDAR REFORM

Last summer the United Nations Economic and Social Council adopted a resolution introduced by India asking all nations, whether members of the UN or not, to study the question of calendar reform and present their views by May of this year.

On March 21st, the United States replied officially that this government does not favor any action by the UN to change the present calendar. The reasons given are that there is no evidence that a majority of the population of this country favors calendar reform at this time, and that large numbers have expressed objections to change, on religious grounds. The government statement holds that it would be inappropriate for the UN to sponsor any change in the calendar "that would conflict with the principles of important religious faiths."

☆ ☆ *SKY AND TEACHER* ☆ ☆

Sponsored by the
Teachers' Committee of the American Astronomical Society

ASTRONOMY IN THE COLLEGES

THE Teachers' Committee has recently compiled enrollment figures in beginning astronomy courses at the colleges and universities of the United States. The data were collected on a regional basis, and the author extends thanks to the 25 astronomers who participated in making the survey. Our information refers to the school year 1953-54.

It turns out that astronomical study is offered either as a separate discipline, or as a significant fraction of a physical science survey course or general education course, at 344 of the 1,850 institutions of higher learning in the country. The total enrollment at the 344 institutions for which our data are complete was close to 1,100,000 in the fall of 1953. Total enrollment figures range all the way from less than 100 for the smallest schools to more than 30,000 on the campuses of the University of California.

Of these 344 institutions, 151 offer astronomy as an independent and self-contained course, 100 teach it only as a part of a general survey course, and 93 offer courses of both types. Thus, independent astronomy is given at 71 per cent of the schools, and it is included in survey courses at 56 per cent of them, but the mean annual course enrollment in the first is only 55 as compared with 144 in the latter.

Dividing all 344 schools according to total enrollments into large (5,000 or more), middle, and small (less than 1,000), two conclusions are evident. First, regular astronomy courses are strongest at the large institutions while survey courses are relatively stronger at the smaller schools. Probably budgetary reasons tend to exclude independent astronomy courses in the smaller colleges. Second, the percentage of students who study astronomy increases markedly as we move from large to small schools. It is likely that at the large schools most students are enrolled in some undergraduate branch of learning in which astronomy cannot be elected for credit, or are engaged in graduate study. It is impossible to assess these effects from the available data, but our information as it stands shows that the ratios of annual enrollment in astronomy to total enrollment per semester in large, medium, and small schools are respectively one, two, and three per cent for conventional astronomy; one, five, and eight per cent for survey courses; and thus two, seven, and 11 per cent for some sort of astronomical learning.

For all schools together, total annual enrollment in regular astronomy courses amounts to about 13,500, and in survey courses to about 28,000—a yearly total of 41,500 studying astronomy of some sort. The ratios of annual astronomy enrollment to total semester enrollment, for all 344 schools together, are 1.3 per cent for independent astronomy courses, 2.6 per cent for the survey courses, and 3.9 per cent for both together.

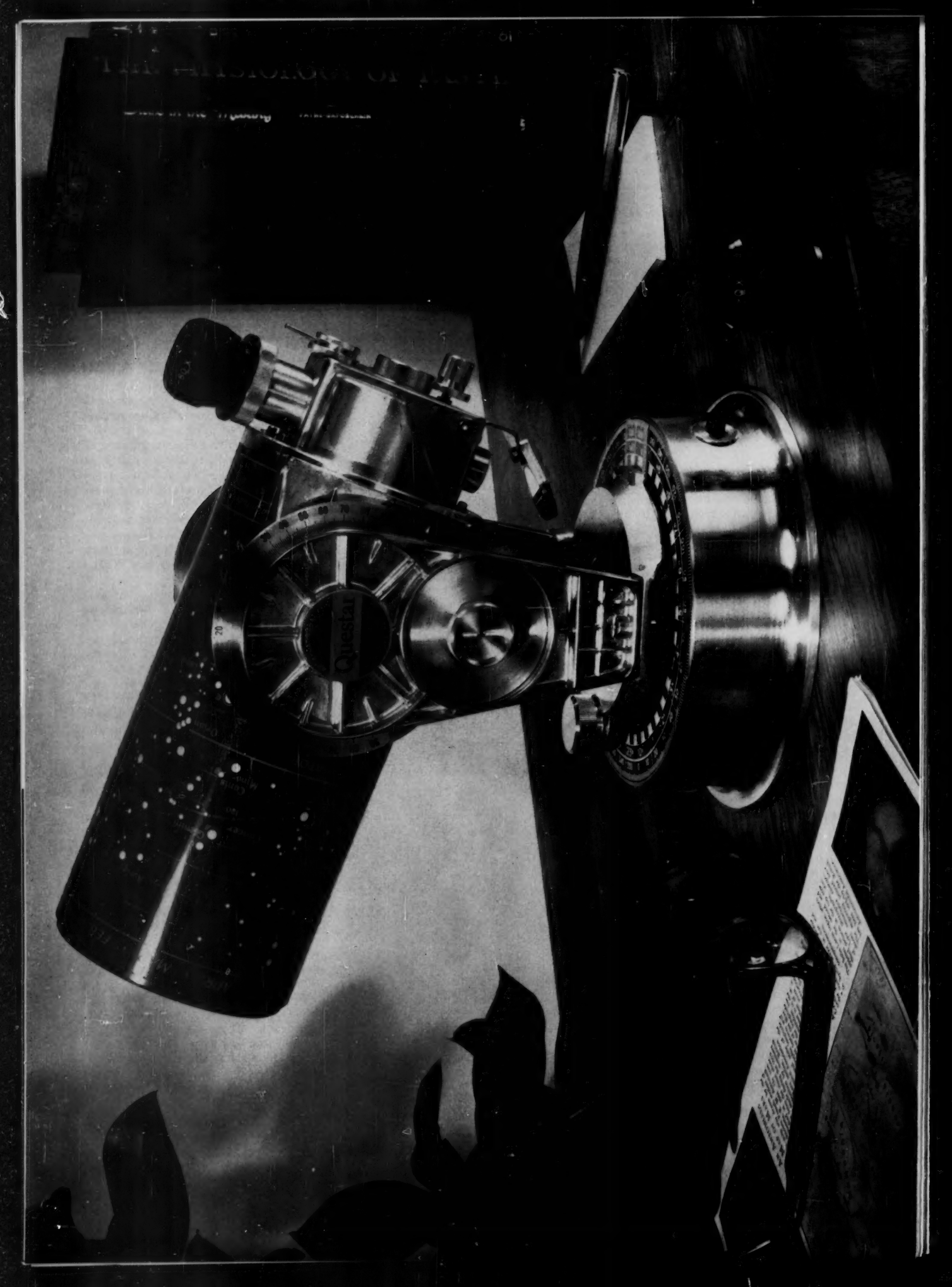
The 11 institutions with annual enrollments in regular astronomy exceeding 250 are the University of Michigan, with more than 600 students, followed in order by Minnesota, Dartmouth, Southern California, California, at Berkeley, Maine, Mississippi State, California at Los Angeles, Illinois, Columbia, and Indiana.

From the point of view of percentage participation in r e g u l a r astronomy courses, there are only six four-year schools at which the ratio of annual astronomy enrollment to total semester enrollment exceeds 10 per cent. (These calculations tend to favor the smaller colleges because their total enrollment figures do not in general include graduate students or students in special undergraduate curricula.) There are no large schools in this group of six. The two middle-sized colleges are Dartmouth, where nearly 60 per cent of all graduating students have experienced astronomy, and the University of Maine, where close to half of the students take astronomy at some time during their college careers. The four small colleges in this group are led by Agnes Scott College in Georgia, where a majority of the students study astronomy during their undergraduate days, followed by Central College in Iowa, Hood College in Maryland, and Augustana College in Illinois.

We can roughly estimate the fraction of all undergraduates who ever receive training in some sort of astronomy. The annual total of 41,500 corresponds approximately to a semester total of 18,000 (with allowance for summer sessions and the small minority of students who take two-semester courses). The total 1953 fall semester enrollment in all institutions of higher learning was about 2,250,000, with about 1,800,000 undergraduates. Thus 18,000/1,800,000 or one per cent of all undergraduate students are taking astronomy in any one semester. With eight semesters available at a four-year college, which embraces the vast majority of all undergraduates, it appears that about eight per cent of all college students in the United States get acquainted in the classroom with moon, stars, and galaxies.

There are many colleges and universities at which vigorous and successful programs of astronomical instruction are under way. On the other side of the ledger, there are a few schools of good size and with sufficient funds available where astronomy is not taught in any kind of course whatever. One hopes that these, along with the more modest-sized liberal arts colleges not now offering astronomy, can find a way to set their sights higher—as high as the stars, because astronomy seems to be increasingly recognized as a very liberalizing subject by reason of its interlocking with other sciences, its scope, and its capacity to excite interest.

STANLEY P. WYATT, JR.
University of Illinois Observatory



THOSE who have seen Questar assure us that it is indeed a remarkable instrument. Most people like the idea of a versatile, completely portable, yet powerful telescope that will give them the rock-steady images and smooth automatic following of large observatory telescopes. They appreciate using an instrument whose smooth controls feel sweet to the hand, whose short tube does not tremble at the slightest touch, and whose total weight is a little over ten pounds. They are impressed by Questar's superb presentation of the moon at 80 and 160 diameters, in the 5-lens Erfle eyepiece whose field is so surprisingly wide.

Perhaps no telescope has ever been so light to carry or so easy to store. Certainly none has ever done so many things so well, or been of interest to so many people, who now turn its powers on all nature's faces, over a great part of the world.

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BOOKS AND THE SKY

A GUIDE TO THE PLANETS

Patrick Moore. W. W. Norton and Co., New York, 1954. 254 pages. $4.95.

THIS is the sequel to the author's popular *A Guide to the Moon*. It is written in his very pleasing style, emphasizing the observational aspects of the planets. We have waited a long time for a good popular book in this field, intended for the small-telescope user. The spirit of Webb's *Celestial Objects for Common Telescopes* is apparent throughout. One gets a good idea of the potentialities of homemade telescopes, as against the idea that only the 200-inch reflector can make useful planetary observations.

Mr. Moore begins by discussing the scale of the solar system and the present-day hypotheses regarding its formation. The individual planets are next considered in turn. In the chapter on Mercury, older observations by Schiaparelli and Antoniadi and modern ones by Dollfus at the Pic du Midi are used to show that the question of a thin atmosphere is still open.

The Venus chapter has a good discussion of the faint dusky markings most ardent observers perceive visually. One remembers the perplexing problem of details on Venus that can be photographed only in ultraviolet light to which human eyes are very insensitive. Yet the visual observer can sometimes see very similar detail. A recent example is a drawing by Henry Squyers in December, 1954, who independently recorded the same major markings as did ultraviolet photographs with the 100-inch Mount Wilson reflector.

There is also an account of three rotation periods suggested for Venus, near 24 hours, about 25 days, and 225 days. The famous "ashen light" is taken up, as well as some of the very fanciful explanations for it.

Mars has been considered mostly from the viewpoint of the more recent work, notably the spectrographic studies by G. P. Kuiper. The bright spots observed by T. Saheki, which he described in *Sky and Telescope* for February, 1955, are also mentioned. More important is as intelligent a discussion of the canals as is possible at this time.

An extensive description of the two semipermanent Jovian features, the red spot and the south tropical disturbance, is a fine asset to the chapter on Jupiter. One must remember that practically all of our present-day knowledge of these features is due to concerted effort on the part of good amateur observers.

Jupiter's closest satellite, J V, discovered by E. E. Barnard, is called "Amalthea" in this book, but I don't feel that the name has ever been widely accepted. All the other satellites, except for the four Galilean moons, are known merely by their Roman numerals.

The lack of agreement between the rotation rates in various latitudes of Saturn is mentioned. Here is another excellent opportunity for the amateur. The list of ring divisions should now be increased by two or three, or drastically reduced, depending on one's definition of a ring division. The dusky ring outside of ring A is now certainly confirmed, and henceforth will probably be called ring D.

It is good to see Mr. Moore point out that occasional spots are observed on Uranus, and that they are within the reach of medium-sized telescopes. The agreement with the accepted rotation period of the positions of a spot observed by W. Haas and O. Ranck demonstrates that these markings can be seen by amateur observers.

The story of Pluto is expressed very well, including some of the uncertainties about its diameter. This planet is well placed during the next 50 years for observers with 12-inch telescopes, if they possess a chart of the region showing stars down to 15th magnitude.

The appendixes are of great value to the book. They include items on methods of observing the planets, astronomical groups interested in planetary work, and useful programs for the amateur. The only thing lacking is direct instructions for computing the longitude of the central meridian of a planet for the time of observation. The index is very adequate.

Anyone even remotely interested in the planets should have this book on his shelf. I strongly recommend it to all amateurs.

THOMAS A. CRAGG
Inglewood, Calif.

OUR AMERICAN WEATHER

George H. T. Kimble. McGraw-Hill Book Co., Inc., New York, 1955. 322 pages. $4.75.

THERE is nothing quite like American weather anywhere else in the world, writes Dr. Kimble in his well-organized and extremely informative survey of the American weather scene. Though our weather is made up of the same basic elements that are found all over the globe, it is in the sharply accented sequences that American weather comes by its unrivaled individuality.

Dr. Kimble finds two main causes for this. Our atmosphere is the scene for the meeting of no less than six contrasting air-mass types that are found in action every day somewhere on or near the North American continent. And, furthermore, American weather reflects our greatly varied terrain with its innumerable changes in elevation, type of cover,

and mixture of land and water surfaces.

Dr. Kimble sets out to catch something of the "style" of the weather scene as it changes through the months of the year. In basic approach the book resembles the well-known work of Charles F. Brooks, *Why the Weather* (1924 and 1935), on which many amateur weathermen cut their meteorological molars. One chapter in *Our American Weather* is devoted to each month of the year, instead of a chapter to each season as Dr. Brooks chose to divide his material. Admittedly, some of the events and material discussed under certain months do not always occur in that particular month, but the plan gives some order to a subject that often defies literary organization.

January is devoted mainly to cold, February to snow, March to the winds, April to frost and showers, May to tornadoes and hail, June to clouds, July to thunderstorms, August to heat and humidity, September to hurricanes and hay fever, October to Indian summer and signs of the sky, November to drought and smog, and December to resort weather and old-fashioned winters. In each chapter a discussion of some of the basic physical principles that control our atmosphere is introduced, and this is done without mathematics.

The author approaches his task primarily from the viewpoint of the geographer who is interested in describing the events of the daily weather drama. He was the author of a paperback, *The Weather*, which was perhaps the best buy in meteorological literature ever brought on the market. It reflected Dr. Kimble's student and wartime background in the British Isles, but the present volume is a completely new work in view of the author's postwar experiences at McGill University at Montreal and more recently in New York City and vicinity. Practically all the references are to North American weather phenomena, with here and there observations of events that occurred right in the author's New Jersey back yard. These give a personal touch of reality to the discussion, a quality that is so lacking in most books on meteorology.

Readers of *Sky and Telescope* will be particularly interested in Dr. Kimble's discussion of the superior mirage, a condition arising when more than one inversion of the usual temperature strata is present. These cause out-of-position stars to appear in telescopes and unidentified aircraft to flit about radar scopes. "It is not without significance," concludes the author, "that a considerable percentage of the corroborated 'saucer' stories can be traced to parts of North America and to times of the year in which inversions capable of producing superior mirages are known to have been present."

Another subject of popular interest that receives attention is rainmaking. Dr. Kimble shows a marked lack of enthusiasm for both the activities and the claims of the rainmakers, or 20th-century alchemists, as he calls them. He is doubtful whether more harm or good will result from this modern tinkering with the atmosphere. And, further, there is no telling whether the rainmakers can control their inventions once under way. He concludes, "there is something to be said for doing nothing much about the weather."

There is one omission from the book that the present reviewer regrets. No daily weather maps are reproduced, nor is there any co-ordinated discussion of the general circulation patterns or of the movement of storm types across the country. There are a number of stereotype charts of averages and means, and these seem to reflect the fascination of the geographer with these data. But the weather is never normal, rather being made up of a number of greatly contrasting daily patterns. The daily weather map helps to simplify and to present this multiplicity in graphic form.

Perhaps this was beyond the author's purpose. Perhaps this job will be done by a synoptic forecaster who has the literary ability to put his wisdom in print. At any rate, the classic book on the American weather scene, if it is ever produced, will have to devote major space to our everyday weather as typified by the newspaper weather map that is read by millions throughout the country every day.

DAVID M. LUDLUM
Editor, *Weatherwise*

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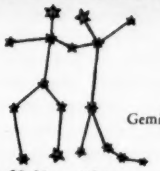

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PHYSICS OF THE PLANET MARS
An Introduction to Areophysics

Gerard de Vaucouleurs. The Macmillan Co., New York, 1954. 365 pages. $10.00.

HISTORICALLY, the study of Mars has an interesting resemblance to the growth of knowledge about its neighbor planet, Earth. The great age of geographical discovery in the 15th and 16th centuries finds its parallel in the telescopic mapping of the Martian surface since 1877. But just as in the 19th century scientific interest turned from geographical exploration to geophysics, so the application to Mars of the tools of physics, both observational and theoretical, has given rise to the new science of areophysics, beginning about 1924.

Gérard de Vaucouleurs writes about this fruitful new attack on the red planet with spectrograph, photoelectric photometer, thermocouple, and polarimeter. The central questions have now become the amount and composition of the Martian atmosphere, the climatology of Mars, the physical nature of the planet's surface, and the structure of its interior. The present book is a translation and revision by the author of his French book of 1951, *Physique de la Planète Mars*. He remarks with some justice: "This revised edition covers substantially all available information on the physics of Mars on the threshold of the new phase that the 1954 and 1956 perihelic oppositions will probably open."

While there are many unsolved problems, the main outlines of the physical picture of Mars emerge clearly from de Vaucouleurs' critical analysis.

The Martian atmosphere, he concludes, has at ground level a barometric pressure of about 64 millimeters of mercury, as against 760 for the earth. In contrast to what was said in the earlier edition, three types of Martian clouds are now distinguished: tenuous violet clouds near the sunrise and sunset limbs of the planet; low-level yellow dust clouds; and white clouds, which from the polarization measurements of A. Dollfus appear to be made up of ice crystals.

Both observational and theoretical data point to average yearly Martian equatorial temperatures 20 to 30 degrees centigrade colder than on the earth, and 70 to 80 degrees colder in the Martian than in terrestrial polar regions. Nevertheless, climate on Mars is a looser conception than on the earth, where the temperature difference between the ground and the air just above it is always small; for Mars this difference is about 35 degrees centigrade.

Perhaps the most striking recent observational advances in the study of Mars are G. P. Kuiper's and Dollfus' demonstrations that the polar caps are H_2O, probably in the form of a frost layer about one millimeter thick. However, de Vaucouleurs doubts that the dark fringe that surrounds a shrinking polar

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cap can be liquid water, because of the extreme dryness of the planet's atmosphere. He suggests that the fringe is merely an enhancement of pre-existing surface detail.

The central issue of the Martian problem, as de Vaucouleurs calls it, is whether the dark surface markings indicate some form of vegetation or not. He wisely suspends judgment, although regarding Kuiper's conjecture of lichens or dry mosses as a possibility. The main strength of Kuiper's view, as I interpret de Vaucouleurs' words, is the inadequacy of the older non-vegetation hypotheses. Since the writing of this book, however, D. B. McLaughlin has pointed out good reasons for supposing the dark markings to be drifts of volcanic ash (*Sky and Telescope*, September, 1954, page 372). Clearly the whole question of the interpretation of the dark regions will remain fluid until decisive observations are made.

While *Physics of the Planet Mars* is primarily a handbook for the specialist, its author began his Martian studies as an amateur, and has kept his presentation simple enough for the serious amateur, who can find herein many suggestions for worthwhile observing programs.

In particular, careful records of Martian cloud phenomena are desirable: "One of the greatest difficulties at the present time in studying the atmospheric circulation on Mars is the scarcity of reliable data on cloud motions. A systematic and prolonged study of the lasting cloud formations and of their displacements is the preliminary requirement for the establishment of seasonal wind maps of Mars. Such a study, which calls essentially for great continuity, is well within the range of small instruments."

Another part of the book that should be carefully read by the amateur planetary observer is pages 314-325, which describe how estimates on a numerical scale of the relative brightness of Martian surface features can lead to far-reaching conclusions.

For anyone who wants a more complete report than popular books give on recent developments in Martian studies, *Physics of the Planet Mars* is indispensable.

J. A.

CLIMATIC CHANGE

Harlow Shapley, editor. Harvard University Press, Cambridge, 1953. 318 pages. $6.00.

THIS BOOK resulted from a two-day conference called in 1952 by the Rumford committee of the American Academy of Arts and Sciences. Twenty-two contributors treated the importance of changes in climate from many standpoints—astronomical, physical, chemical, biological, geological, paleontological—not only for the planet Earth but for other members of the solar system and other star systems.

Using very conservative figures, Dr. Shapley submitted that there should be 10^8 other planets within the confines of the known metagalaxy suitable for the support of life. In our solar system only Earth, Venus, and Mars have the necessary shape of orbits and distance from heat supply. We can do little more than speculate regarding the last two until more refined observational techniques have been developed.

The climatic phenomena on our own planet depend largely upon incoming solar radiation. A chapter by H. Wexler discusses the effects of variations in the solar constant and of the dissemination of volcanic materials into the atmosphere.

The cause of the ice ages receives much attention. John Wolbach finds that cooling of the earth during the last two billion years does not account for the seven periods of major glaciation from the late Pre-Cambrian to the present, and changes in the geography of the land masses are also insufficient. Similarly, A. J. J. van Woerkem reports that ". . . changes in insolation, caused by the changes in the earth's orbit and in its axis of rotation, are insufficient to explain the periods of glaciation." D. H. Menzel's analysis of the problem tends to point toward an association of the ice ages with volcanism.

Climatic cycles in historic times are discussed by Victor Conrad. Temperature

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records from 1770 to 1939 show that for northern Germany the winters since 1871 have been warmer than those preceding; no periodicity above or below normal was detected.

An important group of chapters deals with means of tracing climatic changes in the more remote past. Glacial geology, tree rings, and radioisotope dating are all considered, the last by J. Laurence Kulp. Elso S. Barghoorn summarizes paleobotanical data, which indicates that throughout geologic time since early Paleozoic, present climatic zones are much more numerous and diversified than during any previous period.

Fossil vertebrate animals, writes E. H. Colbert, furnish abundant evidence of climatic conditions from early Paleozoic to the close of the Mesozoic. Except for comparatively short periods, temperature was much more uniform over the earth, both on land and in the sea, than at present. Cold-blooded animals are better indicators than warm, and climatic zones as we know them are a Tertiary and Recent development.

All the chapters in the book are well-documented with references to pertinent literature. They should have a wide appeal to the intelligent reader. Some may consider the omission of an index a handicap.

G. DALLAS HANNA
California Academy of Sciences

NEW BOOKS RECEIVED

ADVANCES IN GEOPHYSICS, II, *H. E. Landsberg*, editor, 1955, *Academic Press*. 286 pages. $7.50.

This volume is the second in a series of reports on recent progress in the earth sciences; its predecessor was reviewed in the June, 1953, issue of *Sky and Telescope*.

Although none of the five contributions is directly astronomical, all have astronomical implications. Thus, I. I. Gringorten's account of statistical methods in objective weather forecasting is valuable to persons interested in forecasting solar activity. The extensive chapter by W. J. Pierson, Jr., on wind-generated water waves contains much that could be adapted by astronomers working on turbulence or on the analysis of light curves of the less regular variable stars.

Other chapters deal with radar meteorology, geological dating by radioactive methods, and seismographs. There are extended bibliographies and indexes.

ASTRONOMY, *Robert H. Baker*, 6th edition, 1955, *Van Nostrand*. 528 pages. $5.50.

Since the appearance of its first edition in 1930, this has been a well-known elementary college text. It is now largely rewritten, and includes topics such as the revision of the distance scale of the galaxies, and recent advances in radio astronomy. Three fifths of the book are devoted to the solar system, and about 200 pages to the stars and extragalactic systems.

SUNS, MYTHS AND MEN, *Patrick Moore*, 1954, *Frederick Muller Ltd.*, London E. C. 4. 192 pages. 12s 6d.

Writing in a popular vein, Mr. Moore tells of the growth of astronomy from cave men to the astronauts of the future. Here the general reader will find some of the fanciful views once held about our solar system, and an outline of the factual picture that has taken their place.

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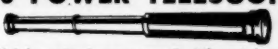

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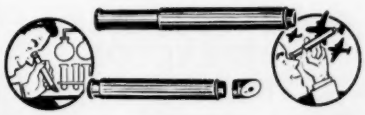

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WHAT'S NEW AT EDMUND'S

by Norman W. Edmund

Dear Fellows:

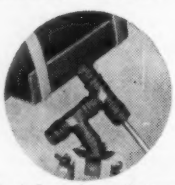
My face is a little red this month. For years we had been telling our customers that we didn't have any sun diagonals. Recently, one of **Sky and Telescope's** readers, who stopped at our retail store, pointed out that our war-surplus unsilvered Penta Prisms make excellent sun diagonals for low and medium powers. Since the two reflecting surfaces are not silvered, only 1/600 of the light is reflected.

Like all prism-type solar diagonals, to protect the observer's eyes from the sun's light and heat, especially at the focus of a telescope, a dark solar glass should be used over the eyepiece, or a filter or welder's goggles. Or, to be sure the heat will not crack the eyepiece, you can stop down the objective, with a disk containing a hole not over two inches in diameter, or with a central diaphragm that leaves a ring or annulus ½-inch wide around the outside of the lens or mirror. Thus, our Penta Prism, listed on the facing page, makes an economical sun diagonal.

This month we are able to show you a picture of our new rack-and-pinion eyepiece holder for refractors. Look it over.

We have finally done something about telescoping tubing for the experimenter. It's made of kraft paper and black on the inside. There are 12 pieces in a package. Each one telescopes into the next one. Sizes by I.D. are ½, ⅝, ¾, ⅞, 1, 1¼, 1½, 1¾, 2, 2¼, 2½, and 3 inches. They are all 3 feet long. Package sells for $8.00 delivered to you. Order Stock No. 80,042-Y.

PALOMAR, JR. EQUATORIAL MOUNT



This mount will help you find and "follow" a star with a minimum of effort! Point the polar axis at the North Star, adjust the tripod legs for its elevation, and tighten the lock nut. The telescope tube will now describe the same arc as a heavenly body moving through the sky.

Supplied complete with tripod legs for reflectors or refractors up to 4¾" diam. The taller tripods are used for refractors. Made of hardwood. Same mount supplied with either tripod.

Stock #85,009-Y
(Tripod legs 40" long) ..... $18.95 f.o.b.

Stock #85,015-Y
(Tripod legs 60" long) ..... $22.50 f.o.b.

6" REFLECTING TELESCOPE

Complete with heavy duty equatorial mounting and tripod. Tripod has cast aluminum head and rugged wooden legs for stability. (Folds for storage.) Equatorial mount has 1" diameter shafts with Boston bronze bearings. 5-lb. counterweight for perfect balance. Locks on both declination and polar axis. Polar axis set at 40°; latitude adjustment made with tripod legs. Black crinkle finish on mount. Telescope tube made from plastic impregnated fibre. White enamel finish on outside. Rack-and-pinion focusing eyepiece mount. 7X achromatic finder with crossline reticle. 6" Pyrex parabolic mirror—48" F.L. (f/8)—aluminized and overcoated—guaranteed to give theoretical limit of resolution. Mirror mount machined cast aluminum. Combination eyepiece gives 60X and 120X. Extra eyepiece available for 200X. Shipping weight 75 lbs.

Stock #85,024-Y ..... $195.00 f.o.b.

6" & 8" EQUATORIAL MOUNT

As Illustrated on 6" Telescope Above

Heavy ¾" steel plate base with five ½" holes for attaching to your post or tripod. Welded construction throughout. One-inch shaft with Boston bronze bearings. Bearings and housing 6" long. 5-lb. counterweight for balance on 16"-long shaft. 1¾" diameter locking knobs on both declination and polar-axis shaft. Polar axis set at 40°; latitude adjustment made with tripod legs. 14" cradle securely holds from 4" to 10" diam. telescope tubes. Mount weighs 27 lbs. and is approximately 14" high.

Stock #85,023-Y ..... $49.50 f.o.b.

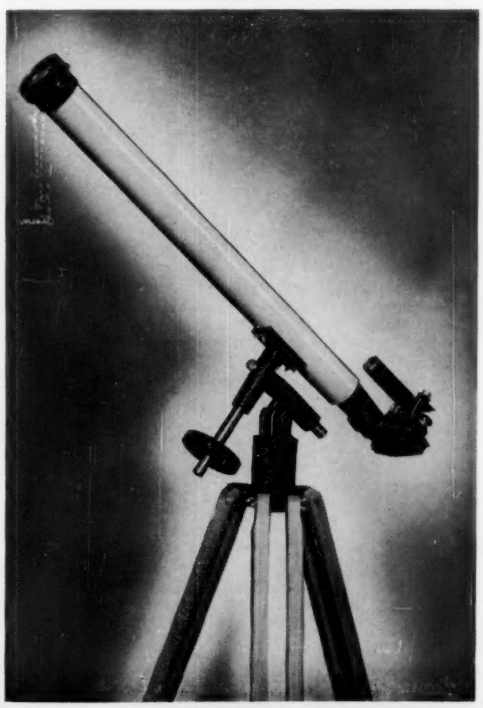
3" REFLECTOR ASTRONOMICAL TELESCOPE KIT

Complete parts—no machining—easily assembled; a nine-year-old can do it! All nuts and bolts supplied. Nothing extra to buy. Kit includes 3" spherical mirror 30" F.L., aluminized and overcoated. Guaranteed to resolve detail right up to theoretical limit. Tripod 40" high with cast-iron tripod head, all holes drilled and tapped (all machining finished). Other parts made from ⅛" thick steel all ready to assemble. Smoothly functioning equatorial mounting. Locks on both polar and declination axes. Polar axis at 40°; latitude adjustment made with tripod legs. Natural grain finished hardwood tripod legs. Heavy 3/16"-wall kraft telescope tube with special black glare-reducing liner. Eyepiece mount has slide focus adjustment. Mirror attaches on new type mounting with pressure-sensitive adhesive tape eliminating distortions. Mirror is ventilated. 60X eyepiece included. 90X and 120X eyepieces available at extra cost. Crosshair finder parts included with mountings. Parts zinc plated to prevent rust. A real kit in every respect. Can also be used terrestrially. Nothing extra to buy. Money back guarantee.

Stock #85,025-Y ..... $29.50 f.o.b.

40-90-190 POWER 3" REFRACTOR TELESCOPE

Complete With Equatorial Mount, Tripod and Prism Finder!



Here's a telescope bargain you have never seen before. This telescope uses the 3" objective described on the opposite page. Telescope is complete — no extras to buy. Look at all of these wonderful features. Erect image. Roof prism. Bends the light at 90° angle for comfortable viewing at zenith and also for terrestrial use. Three eyepieces supplied with the telescope: 6.0 mm. for high-power astronomical viewing, 12.5 mm. for medium power for viewing moon, planets, etc., and 28 mm. for low-power terrestrial and astronomical use. Small focusing eyepiece mount takes 1¼" outside diameter eyepieces. Contains built-in filters which can be changed by turning a small knob. Filters are red, yellow, neutral, and clear for use in planetary work.

The 8-power finder telescope has a real achromatic objective. Bends the image in a right angle for convenience in transferring your eye from the finder to the telescope. The heavy-duty equatorial mount can be adapted for all latitudes in astronomical viewing. It is quick and flexible for terrestrial use. Specially designed to adapt easily to slow-motion mechanism. Heavy-duty tripod adjustable for viewing at all heights. Overall length of telescope approximately 45". Shipping weight 100 lbs.

Stock #85,019-Y ..... $195.00 f.o.b. Barrington, N. J.

EDMUND SCIENTIFIC CORP.

ACHROMATIC ASTRONOMICAL TELESCOPE OBJECTIVES

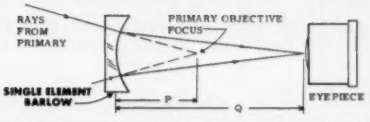
Real Quality at Bargain Prices
Make Wonderful Refractors

For three years we checked U.S., German, and Japanese manufacturers looking for one who could produce really good telescope objectives at a low price. A few times we ordered samples only to be disappointed in quality or final price. Finally, we found a Japanese optical engineer who designed some excellent astronomical objectives. We place orders with him. He then has these made, checking each one for quality. Thus, we are able to offer objectives we believe to be as good as those selling for two or three times our price.

Our 3" and 4" diameter objectives are air-spaced achromats, as air-spacing gives the lens designer four surfaces with which to correct aberrations, instead of only three as in a cemented achromat. The results are a beautiful, color-free image, sharp, clear, with very flat field, no bad zones, and full correction against coma.

Stock No.	Diam.	F.L.	Price	Comments
30,166-Y	3"	45"	$28.00	Not coated
50,106-Y	4"	60"	60.00	Not coated
50,107-Y	4"	60"	69.00	Coated on four surfaces

DOUBLE AND TRIPLE YOUR TELESCOPE'S POWER with a BARLOW LENS



WHAT IS A BARLOW? A Barlow lens is a negative lens used to increase the power of a telescope without resorting to short focal length eyepieces, and without the need for long, cumbersome telescope tubes. Referring to the diagram above, a Barlow is placed the distance P inside the primary focus of the mirror or objective. The Barlow diverges the beam to a distance Q. This focus is observed with the eyepiece in the usual manner. Thus, a Barlow may be mounted in the same tube that holds the eyepiece, making it very easy to achieve the extra power.

The new power of the telescope is not, as you might suppose, due to the extra focal length given the objective by the difference between P and Q. It is defined as the original power of the telescope times the quotient of P divided into Q!

ACHROMAT OR SIMPLE BARLOW? An achromatic Barlow lens will give best results, but our low-priced single-element lens will give you 90% of the performance of the achromat. In fact, on and around the axis, the image will be just as good, with slight additional color at the edges of the field. SINGLE ELEMENT BARLOW — FOCAL LENGTH 1-5/16".

Stock #30,175-Y. Unmounted, O.D. 1-3/16". Coated. Fits in tubing listed below. $3.00 ppd.

Stock #30,140-Y. Mounted Achromatic Barlow Lens ..... $15.00 ppd.

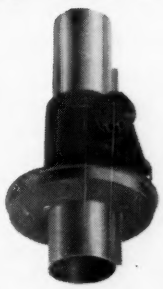
BRASS TUBING

2 pieces, 3" long, slide fitting. Blackened brass. I.D. 1-3/16", O.D. 1-5/16". To fit single-element Barlow above. Complete directions.

Stock #40,165-Y ..... $1.25 ppd.

Rack & Pinion Eyepiece Mounts

For Reflectors



For Refractors

Now you can improve performance in a most important part of your telescope — the eyepiece holder. Smooth, trouble-free focusing will help you to get professional performance. Look at all these fine features: Real rack-and-pinion focusing with variable tension adjustment; tube accommodates standard 1¼" eyepieces and accessory equipment; lightweight aluminum body casting; focusing tube and rack of chrome-plated brass; body finished in black wrinkle paint. No. 50,077-Y is for reflecting telescopes, has focus travel of over 2", and is made to fit any diameter or type tubing by attaching through small holes in the base. Nos. 50,103-Y and 50,108-Y are for refractors and have focus travel of over 4". Will fit our 2⅜" I.D. and our 3⅜" I.D. aluminum tubes respectively.

Stock #50,077-Y (less diagonal holder) $9.95 ppd.
Stock #60,035-Y (diagonal holder only) 1.00 ppd.
Stock #50,103-Y (for 2⅜" I.D. tubing) 12.95 ppd.
Stock #50,108-Y (for 3⅜" I.D. tubing) 13.95 ppd.

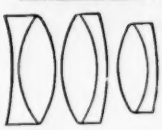
7X — FINDER TELESCOPE — ACHROMATIC

Stock #50,080-Y Finder alone, less ring mounts $9.95
Stock #50,075-Y Ring mounts per pr., $4.95

ASTRONOMICAL TELESCOPE TUBING

Stock No.	I.D.	O.D.	Lgth.	Description	Price
80,038-Y	4⅞"	5¼"	46"	Spiral-wound paper	$2.50
85,008-Y	7"	7½"	60"		4.00
85,011-Y	2¾"	3"	48"	Aluminum	6.00
85,012-Y	3¾"	4"	60"		8.75
85,013-Y	4¾"	5"	48"		9.00
85,014-Y	6¾"	7"	60"		15.00

All tubing is shipped f.o.b. Barrington, N. J.



MOUNTED ERFLE EYEPIECE

68° FIELD OF VIEW

Consists of 3 coated achromats in metal mount with spiral focusing. F.L. 1¼", Diam. 54 mm., length 54 mm. War surplus. Govt. cost about $84.00. This is the type war surplus bargain that will be talked about in years to come. Buy while you can. Our price will jump soon.

Stock #5160-Y, $12.50 ppd.

ADAPTER

Provides 1¼" diameter mount to fit standard eyepiece holders.

Stock #30,171-Y ..... $3.95 ppd.
1¼" diam.

HUYGENS EYEPIECES

Here are some really terrific values in eyepieces! The three eyepieces listed below are manufactured by one of the world's best producers of optical components. We have searched the world's markets, including Germany and France, to find a real quality eyepiece. The image clarity, the workmanship evidenced in the metal parts, will prove the skill and experience of Goto Optical Company, Tokyo. Guaranteed terrific buys at these low prices!

HUYGENS TYPE — STANDARD 1¼" DIAM.
6 mm. (¼") Focal Length
Stock #30,063-Y ..... $8.50 ppd.
12.5 mm. (½") Focal Length
Stock #30,064-Y ..... $8.00 ppd.

COMBINATION EYEPIECE
Stock #30,065-Y ..... $9.00 ppd.

This Huygens eyepiece, used in different arrangements of the lens elements, gives focal lengths of 10 and 20 mm., allowing you to double the power of any objective or primary mirror. Standard equipment with our Palomar, Jr. reflecting telescope. Easy directions for assembling for different powers are included.

WAR SURPLUS TELESCOPE EYEPIECE

Mounted Kellner Eyepiece, Type 3. 2 achromats, F.L. 28 mm., eye relief 22 mm. An extension added. O.D. 1¼", standard for all types of telescopes. Govt. cost $26.50.

Stock #5223-Y, $5.95 ppd.

MAKE A SUN DIAGONAL

Because it is unsilvered, this PENTA PRISM transmits only .0016 of the light it receives, making it an excellent sun viewing diagonal, if used with proper precautions. Entrance and exit faces 1" and 1" approximately.

Stock #3262-Y $3.75 ppd.

"MAKE-YOUR-OWN" 4¼" MIRROR KIT

The same fine mirror as used in our Palomar, Jr., polished and aluminized, lenses for eyepieces and diagonal. No metal parts.

Stock #50,074-Y ..... $16.25 ppd.

LATEST MODEL SPITZ Jr. PLANETARIUM

Designed by Armand Spitz. Projects nearly 400 stars, more than 70 constellations in their correct relationships. Use it in any darkened room of the house, project it on walls and ceiling. No batteries, works on ordinary household current. Two simple adjustments that show you the sky as it appears from any point in the Northern Hemisphere . . . for any time of night . . . for any month of the year! Rheostat brightness control. A 32-page book included free of extra cost. Contains valuable information about the stars, provides easy identification of the constellations. Also FREE — illuminated pointer.

About 14" high on a 7" x 7" base. Projection sphere 7" diameter. Weight 3 lbs. Now available supplementary spheres for Southern Hemisphere and "Sky Zoo."

Stock #70,040-Y ..... $14.95 ppd.

SPHERICAL TELESCOPE MIRRORS

Ground, polished, aluminized, silicon monoxide overcoated. You can't buy better quality. Remember, good Spherical Mirrors of f/10 and higher, are perfectly satisfactory for reflecting telescopes.

STOCK NO.	DIAM.	F.L.	PRICE
50,082-Y	3"	30"	$9.95
50,051-Y	4¼"	45"	15.00

360° SETTING CIRCLE

Made of heavy black plastic material with white markings divided into 1 degree. Numbered every 10 degrees. Diameter 4". Hole diameter 2¾" with a ledge 3¼". We also include, free of charge, the U.S. Air Force true air-speed computer, which is an instrument made of two disks of black plastic. Use with the setting circle if you make your own.

Stock #60,039-Y ..... $1.25 ppd.

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STAR SPECTROSCOPE — Imported! Doubles the usefulness of your Telescope. 2¾" long.
Stock #50,023-Y ..... $32.75 ppd.

60° SPECTROMETER PRISM — Polished surfaces 18 mm. x 30 mm. — flat to ½ wave length.
Stock #30,143-Y ..... $8.25 ppd.

BE SURE TO GET FREE CATALOG "Y"
Fantastic variety — never before have so many lenses, prisms, optical instruments, and components been offered from one source. Positively the greatest assembly of bargains in all America. Imported! War Surplus! Hundreds of other hard-to-get optical items. Write for Free Catalog "Y."

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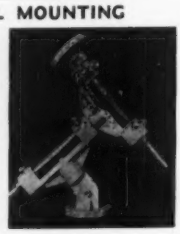
Air-spaced in Bronze Mountings. 84" e.f.l.

U.S. Navy surplus at less than 10% original cost. Strictly a limited supply. We will have to return your money if you are late in ordering. Don't delay! Made-to-order for lunar and planetary workers. These are not "surplus lenses." They were in use by the service for some years and were only replaced by more compact units. While they last, our price **only $59.00 each** plus express charges (collect).

EQUATORIAL MOUNTING

Aluminum and steel



Weight 6 pounds. Height 12", width 13". Finished in grey lacquer. Will handle any telescope up to 6" mirror with 7" or 8" diameter tube. All ¾" diam. steel bearings guaranteed against play. Every motion of the instrument will feel as smooth as silk. The polar axis is adjustable. The telescope can be moved north-south in declination and east-west in time or right ascension to any part of the sky. There is enough extension on the shafts to attach clock drive or verniers.

COMPLETE $35.00 plus parcel post

SAFETY SUN FILTERS

The SAFE AND SANE way to look at the SUN—use our Special Safety Sun Filters. Each one is 50-mm. (2") diameter and 2-mm. (1/16") thick; polished flat on both sides.

1. View the sun **directly** by looking through filter with unaided eyes.
2. Place filter at the **eyepoint** of the ocular and observe with any power after limiting the objective (with a diaphragm) to under 2".
3. Use filter as a limiting diaphragm in front of the objective of the telescope.
   For Winter sunlight use #WF13
   For Summer sunlight use #SF14

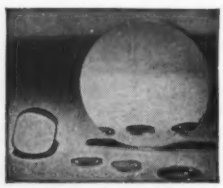
Only $2.00 each or **$3.00 per set** of any 2 above.

PRECISE FOCUSING MECHANISM

For Reflectors or Refractors

Takes Standard 1¼" Eyepiece

Full 1¼" of fine focusing motion with 3" of extension tube. One revolution of knurled knob produces 0.163" motion along optical axis. Absolute centering guaranteed. No play. Will not bind or lock. No rack-and-pinion to strip. Precision manufacture allows smooth, easy positive focusing. Adapted to every type of telescope construction. Drilled to hold diagonal mirror support. Of brass throughout. Weight 1 lb. **$18.50**



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Our regular 5" Aluminized Telescope Mirrors. 67" f.l. 1" blank, crown glass. Regular $17.00, while they last **ONLY $13.00 plus $1.00 P.P.**

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GLEANINGS FOR ATM's

EDITED BY EARLE B. BROWN

Notes on Basic Optics—XIV

O. Chromatic Aberration

As it is in some ways the simplest optical aberration, we shall consider chromatic aberration in optical systems first. As mentioned in March, chromatic aberration arises from the fact that optical glass has a different index of refraction for each wave length of light. In this discussion, we shall deal not only with index of refraction but also with dispersion, which is the variation of index with wave length.

1. **Applications to a Simple Lens.** Equation 26a for the focal length f of a thin lens is

$$\frac{1}{f} = (n - 1)(c_1 - c_2), \qquad (26a)$$

where **n** is the index of refraction of the glass, and c_1 and c_2 are the curvatures of the two surfaces. (In the March, 1955, issue, the left side of this equation was erroneously printed as f instead of 1/f.)

Here it is immaterial what the actual values of the curvatures are; only their **difference** matters, as illustrated in Fig. 42 in March. Calling this difference **c**, it may be substituted for $c_1 - c_2$ in the above equation.

Assuming that there are only two different colors of light to deal with, for instance red and violet (subscripts r and v), we will have two focal lengths, one for each color. Then

$$\frac{1}{f_r} = (n_r - 1)c, \qquad (27r)$$

$$\frac{1}{f_v} = (n_v - 1)c. \qquad (27v)$$

It is clear that the two focal lengths will not be identical unless n_r and n_v are identical, which is never the case for optical glass.

But suppose that we have two thin lenses (a and b) in contact. From our November, 1953, installment, Equation 6a, but now using f′ for EFL, and with subscripts a and b instead of 1 and 2, we have for the reciprocal of their combined focal length:

$$\frac{1}{f'} = \frac{1}{f_a} + \frac{1}{f_b}. \qquad (28)$$

Combining Equations 27r and 27v in turn with 28 gives:

$$\frac{1}{f'_r} = (n_{ra} - 1)c_a + (n_{rb} - 1)c_b, \qquad (29r)$$

$$\frac{1}{f'_v} = (n_{va} - 1)c_a + (n_{vb} - 1)c_b. \qquad (29v)$$

2. **Achromatic Lenses.** To **achromatize** the lens system, we want the combined focal length to be the same for both colors, so we equate 29r and 29v to obtain, after some manipulation, the requirement that

$$\frac{c_a}{c_b} = -\frac{n_{rb} - n_{vb}}{n_{ra} - n_{va}} = -\frac{\delta n_b}{\delta n_a}, \qquad (30)$$

where δn is the difference in index of the particular glass for the two colors in question.

A useful alternative expression of this condition for achromaticity will now be obtained, with the aid of the concept of dispersion. For an intermediate color (subscript d) whose index is n_d, the focal lengths of the lenses will be

$$\frac{1}{f_{da}} = (n_{da} - 1)c_a, \qquad (31a)$$

$$\frac{1}{f_{db}} = (n_{db} - 1)c_b. \qquad (31b)$$

In optical practice, it is convenient to use the **reciprocal dispersion,** ν, for each glass, defined by

$$\nu = \frac{n_d - 1}{n_r - n_v} = \frac{n_d - 1}{\delta n}. \qquad (32)$$

Dividing 31b by 31a, and substituting from 30 and then 32, gives

$$\frac{f_a}{f_b} = -\frac{\nu_b}{\nu_a}, \qquad (33)$$

where the subscript d has been dropped from the focal lengths.

Equation 33 shows that if we combine in contact two thin lenses, one positive and the other negative — whose focal lengths are inversely proportional to the ν-values of their glasses—then the combined focal lengths for the two colors to which the ν-values apply will be identical. Such a combination is known as an **achromatic lens,** or achromatic doublet, or simply an achromat.

The component with the shorter focal length (greater power) has to be the one made of the glass with the larger ν. If the combination is to be a positive lens, the stronger component is the positive one, and therefore it will be made of glass with a high ν value. Generally, this is crown glass while the negative element is flint glass.

HOW TO BUILD A QUARTZ MONOCHROMATOR

For Observing Prominences on the Sun

By Richard B. Dunn

Telescope makers will be interested in having this valuable material easily available for reference, whether or not they construct a monochromator.

Price postpaid, 50 cents

SKY PUBLISHING CORPORATION

Harvard Observatory, Cambridge 38, Mass.

REPRESENTATIVE OPTICAL GLASS CHARACTERISTICS

Type	ν	$n_{A'}$ Potassium 7665	n_C Hydrogen 6563	n_D Sodium 5893	n_{D3} Helium 5876	n_F Hydrogen 4861	$n_{G'}$ Hydrogen 4341	n_h Mercury 4047
Borosilicate Crown:								
511635	63.5	1.50578	1.50860	1.51100	1.51107	1.51665	1.52114	1.52454
Crown:								
523586	58.6	1.51729	1.52036	1.52300	1.52307	1.52929	1.53435	1.53819
Light Barium Crown:								
541599	59.9	1.53529	1.53842	1.54110	1.54117	1.54746	1.55257	1.55645
Dense Barium Crown:								
611588	58.8	1.60439	1.60793	1.61100	1.61109	1.61832	1.62421	1.62867
Extra Dense Barium Crown:								
617539	53.9	1.60979	1.61367	1.61700	1.61711	1.62511	1.63171	1.63675
Crown Flint:								
529516	51.6	1.52217	1.52560	1.52860	1.52869	1.53584	1.54178	1.54633
Light Barium Flint:								
588534	53.4	1.58110	1.58479	1.58800	1.58809	1.59580	1.60212	1.60697
Barium Flint:								
584460	46.0	1.57598	1.58013	1.58380	1.59392	1.59282	1.60033	1.60615
Dense Barium Flint:								
617385	38.5	1.60731	1.61242	1.61700	1.61714	1.62843	1.63811	1.64571
Extra Light Flint:								
559455	45.5	1.55086	1.55495	1.55850	1.55860	1.56722	1.57447	1.58010
Light Flint:								
573425	42.5	1.56425	1.56861	1.57250	1.57262	1.58208	1.59011	1.59637
Dense Flint:								
605379	37.9	1.59536	1.60044	1.60500	1.60514	1.61639	1.62603	1.63361
Extra Dense Flint:								
649338	33.8	1.63754	1.64355	1.64900	1.64916	1.66275	1.67458	1.68397

The table lists the refractive indexes of some common types of optical glass, for various wave lengths that the reader may recognize as those of the strongest Fraunhofer lines in the solar spectrum. The quantity ν is listed here and in glass catalogues (sometimes as V) for the commonly used wave lengths of the C and F lines, 6563 and 4861 angstrom units, respectively. The type number has recently come into fairly common usage—the first three digits represent the refractive index for the sodium D line and the last three digits the ν-value. This avoids the confusion that has sometimes arisen in the past when different manufacturers have assigned the same letter designation (such as EDF-2) to different glasses.

If the difference in index, δn, were exactly proportional to the value $n_d - 1$ for different glasses, it is clear that the ratio in Equation 33 would be unity, and any correction for chromatic aberration would be impossible. But the table shows that the reciprocal dispersion is not the same for different glasses, although most common glass types lie near a curve with a negative slope when plotted as in Fig. 48, where the refractive index for the D line is the ordinate and the reciprocal dispersion is the abscissa. In recent years, a few unusual types of glass have been produced, two of which can be easily recognized in Fig. 48 by their great distance from the main curve. Their special properties are highly prized in optical systems for certain purposes.

It is strongly recommended that all readers who expect to write to manufacturers of optical glass, or to order glass blanks, first read A. G. Ingalls' comments on page 634 of **Amateur Telescope Making—Book Three** (Scientific American Publishing Co., 1953).

(To be continued)

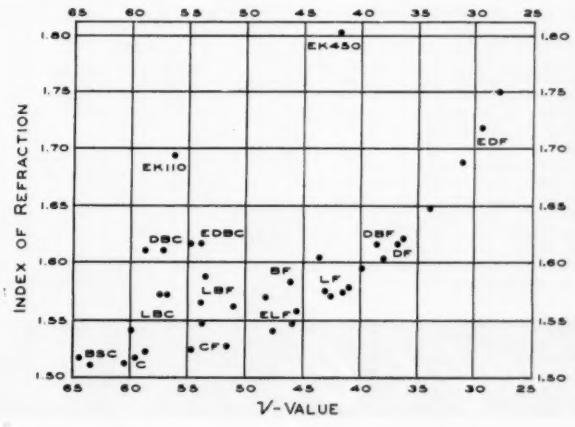
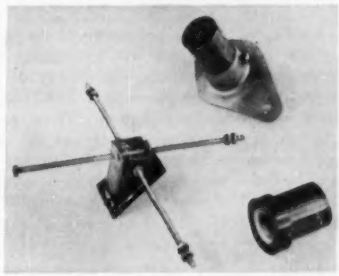


Fig. 48. A chart of the relation of index of refraction and reciprocal dispersion for common types of glass. The crown glasses are generally to the left, the flints to the right.

TELESCOPE MAKING SUPPLIES



4-leg Spider or Diagonal Holder, made of brass, with threaded steel rod. **$1.50**

Eyepiece Holder, brass tube in pressed steel flange. Fits standard eyepiece. **$2.50**

Long Focus Ramsden Eyepiece. 2 polished plano-convex lenses mounted in plastic tube. Standard 1¼" O.D. 30-mm. e.f.l. **$2.00**

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10"	$20.00	$29.00
12½"	$36.75	$51.00

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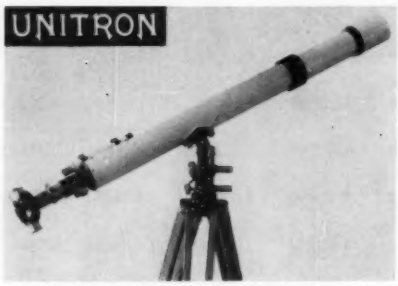

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UNITRON

UNITRON Owners Report . . .

"I recently received my UNITRON and I am astounded at the brilliant clarity and fine quality of the instrument. My sincere commendation goes to your firm for turning out such a fine instrument for such a low price. The precision workmanship and resolving power are beyond belief."
T.C., Lampasas, Tex.

"I received your Model 128 (2.4" Equatorial) and it is a beautiful instrument. Its workmanship is wonderful and the images are so sharp and clear. I used to have a 6" reflector and this is twice as nice and useful."
D.E.A., Davenport, Ia.

"I have just recently received my UNITRON 2.4" Guide Telescope. After looking at and through the instrument, I cannot see how you can sell a telescope such as this for the low, low price that you do. It is magnificent and the image is unbeatable. I have compared this UNITRON with a friend of mine's 6" reflector, and I prefer the UNITRON. I am so much in 'love' with it that I would not part with it for any money."
J.N.G., Bellerose, N. Y.

"Received the UNITRON 3" Equatorial. It seems I can use 200 power just about any time, which I certainly cannot do with my 4¼" reflector. I am well pleased, and I am sure that your promptness, interest, and reliability are the reasons for your large business."
E.M., Mullens, W. Va.

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"Just want to let you know how pleased I am with my UNITRON 2.4" Altazimuth. I had it out in competition with several 4" and 6" reflectors (I am a member of the National Capital Astronomers) and the general reaction was that my refractor performed much better."
W.C.V., Rockville, Md.

"Congratulations on your fine instruments. I am proud to show off my UNITRON at the Los Angeles Astronomical Society."
A.L.H., Norwalk, Calif.

See page 395 and the back cover.

United Scientific Co. 204-206 MILK STREET, BOSTON 9, MASS.

A Six-year Telescope Making Project

STRICTLY a home job, except for forming and welding the tube, the telescope described here took six years to build. All the machine work was done on a homemade lathe which has a concrete headstock with roller bearings embedded in it.

The mirror is a 6-inch f/8 paraboloid, mounted in a hardwood cell turned out to size and lined with cork. The cell is mounted directly on the four lugs at the end of the tube, an arrangement that has needed no adjustment during the five years it has been in service. The diagonal is a first-surface mirror on a spider. A projection lens focusing unit is used as an eyepiece holder, which affords maximum flexibility for change of eyepieces, for celestial and terrestrial focusing, and for visual and photographic observing. There are seven eyepieces of varying quality, ranging in focal length from $\frac{1}{4}$-inch to 2-inch.

The finder has a 2-inch simple plano-convex objective mounted in the large end of a 40-mm. shell case. A diagonal brings its eyepiece to a position near the main eyepiece of the telescope, which is very convenient and eliminates acrobatics near the zenith. There are also sights (coated with luminous paint) for initial alignment on an object, and they have proved their worth.

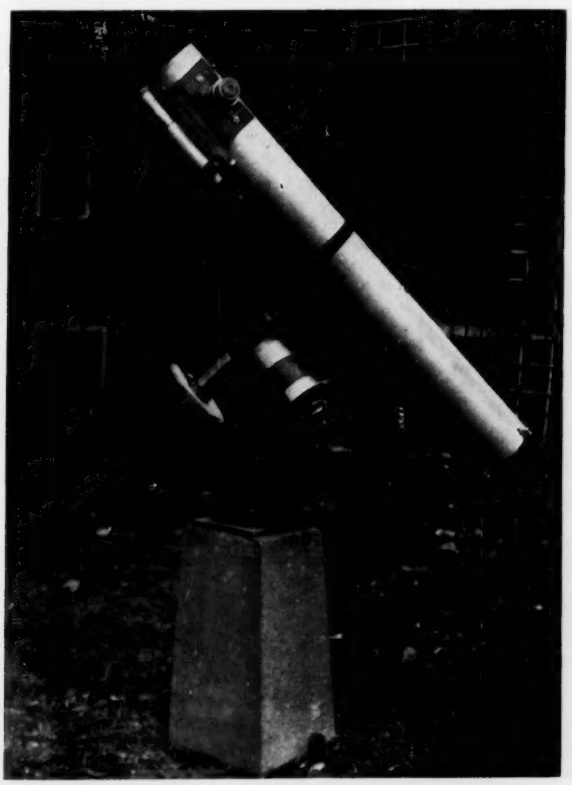
The tube is of 16-gauge steel and is held in a heavy oak saddle by a steel strap; the saddle arcs and strap are lined with felt to prevent scratching the tube. A flat steel ring on the tube fits into a brass slot at the lower end of the saddle to prevent lengthwise slipping.

The main pedestal of the mounting is made of cast concrete, and the roller bearings of the polar axis were embedded in the concrete at the time of pouring. A number of bolts were also sunk into the concrete to provide fastenings for the various mechanisms.

The polar axis is a hollow 2″ shaft running in the roller bearings. A steel disk carrying the right-ascension circle is mounted on the lower end of this shaft. A $\frac{1}{2}$″ spindle forms an extension of the polar axis on which a $\frac{1}{4}$″ plate, several spacer disks, and the right-ascension ring gear are mounted free-running, as shown in the closeup picture. A nut, with spider spokes, tightens on the spindle to form a friction clutch; when this is loosened the telescope can be swung rapidly.

Fastened to the lower worm gear shaft (with knurled knobs) is the clock drive (not shown in the pictures). The upper worm gear can be engaged when the telescope is to be guided, using the hand-wheels.

The declination axis is a $1\frac{1}{8}$″ shaft running in babbitt bearings that were poured on the inside of the pipe fittings. There are no gears on the declination fast and slow motions. The upper end of the pipe tee on the right-ascension axis is machined to form a drum around which fits a free-running clamp. This



In the absence of an observatory building, Franklin Hosken keeps this telescope and equatorial mounting in his garage, from which it is transported to the pier on a special cart. Close-up views of the mounting are reproduced on page 388.

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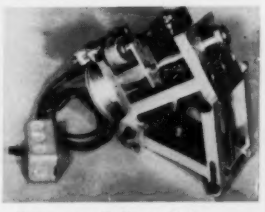

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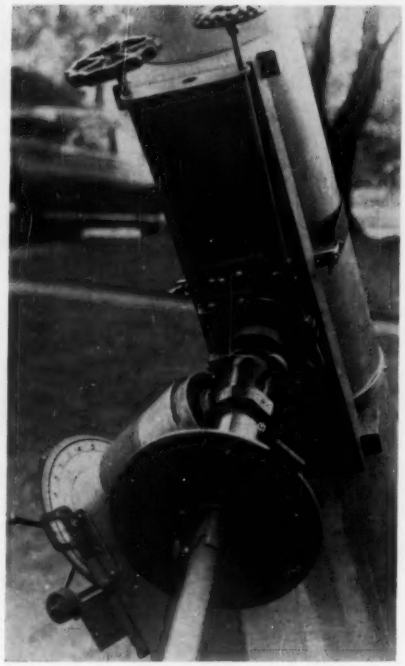
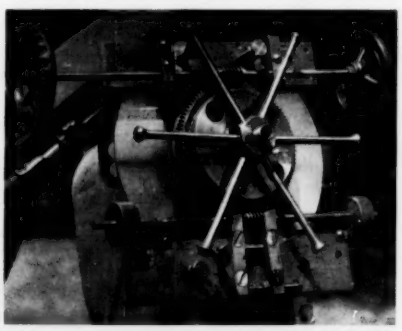


The right handwheel clamps the telescope in declination, and the left is the slow-motion control.

clamp is tightened by the handwheel at the upper right in the picture of this assembly, working through a universal joint. The shaft of the slow-motion handwheel (on the left) has a fine thread which engages threads in a steel plate fastened to the saddle; the end of this shaft presses against a leg of the clamp. When the clamp is tightened and the slow-motion handwheel is screwed against it, the saddle is turned through a small angle. Tension against the slow-motion shaft is provided by a heavy spring fastened between the clamp and the saddle through a high-ratio linkage. The handwheel that tightens the clamp provides the control for fast motion in declination.

A steel plate ½" thick is bolted to the bottom of the concrete mounting pedestal to form its base, and this base can be fastened to a matching plate on the top of the pier. The pier plate rests on a large ball bearing at its center, and by means of adjusting screws can be properly set for latitude and azimuth.

The instrument is housed in the garage, and moved to and from the pier on a cart built especially for the purpose. But the mounting's 86 pounds discourages placing it on the pier except when accurate settings are desired, and observing may be done from the cart. The portable feature is especially convenient because of neighboring trees. The pedestal has a fixed level on its west side. Even on the pier, however, the mounting is not as rigid as might be desired, and when a hand is laid on the tube its effect can be detected in the eyepiece.



This view of the southern end of the polar axis shows the long handles of the spider nut; these are easy to reach from any observing position at the telescope.

In addition to this instrument, we have a 4-inch altazimuth reflector, a 7 × 50 monocular, and three telescopes of lesser importance.

FRANKLIN HOSKEN
11 W. Waltham St.
Calumet City, Ill.

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WE CAN SHIP from stock quality astronomical objectives with the following features:

1. Superior optical design utilizing a larger air separation. Color corrected on C and F and hand corrected on spacing to reduce residuals to a minimum. Completely free of coma.
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3. Quality optical glass precision annealed and held to one ring test plate match.
4. Cell made to precision tolerances and suitably coated to prevent stray light reflections. Each cell engraved with effective focal length and serial number.

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3" C.A.	**45" E.F.L.**	**$ 62.00**
4" C.A.	**60" E.F.L.**	**$138.00**

These objectives are supplied with cells and rigidly tested on double stars for resolving power before being sold.

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Diameter	Focal Length	Each	Diameter	Focal Length	Each
54 mm (2⅛")	300 mm (11.811")..	**$12.50**	81 mm (3 3/16")	622 mm (24½")...	**$22.50**
54 mm (2⅛")	330 mm (13").....	**12.50**	83 mm (3¼")	660 mm (26").....	**28.00**
54 mm (2⅛")	390 mm (15.356")..	**9.75**	83 mm (3¼")	711 mm (28").....	**28.00**
54 mm (2⅛")	508 mm (20").....	**12.50**	83 mm (3¼")	762 mm (30").....	**28.00**
54 mm (2⅛")	600 mm (23½")...	**12.50**	83 mm (3¼")	876 mm (34½")...	**28.00**
54 mm (2⅛")	762 mm (30").....	**12.50**	83 mm (3¼")	1016 mm (40").....	**30.00**
54 mm (2⅛")	1016 mm (40").....	**12.50**	110 mm (4⅜")*	1069 mm (42 1/16")	**60.00**
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7 x 35.....	**20.75**	7 x 50.....	**29.75**
7 x 50.....	**23.75**	8 x 30.....	**22.00**
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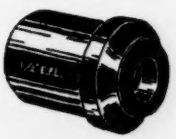

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OBSERVER'S PAGE

Universal time is used unless otherwise noted.

An Amateur Photographs the Moon

SINCE I finished my 12½-inch Springfield-mounted reflector, described on page 58 of this magazine for December, 1953, I have taken over 80 photographs of the moon, in an effort to get an exceptionally sharp picture showing fine detail.

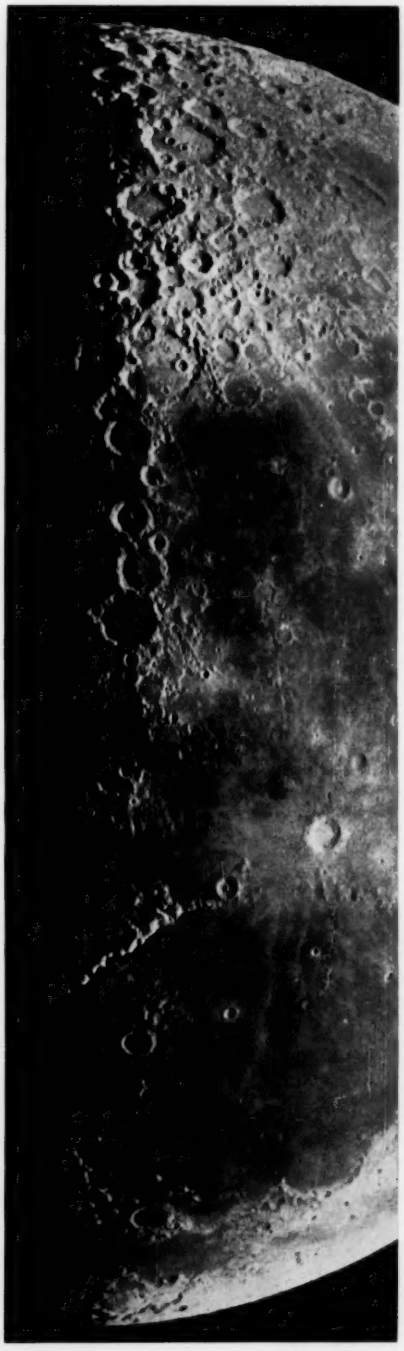
My best result, which is reproduced here, was obtained on August 20, 1954, at 3:59 a.m. CST, when the moon was at last quarter. To give an idea of the amount of detail shown, follow the features along the terminator, starting at the bottom (north), and going upward.

The large crater near the north limb of the moon is Plato, 60 miles in diameter. The black shadow of its ragged mountain wall can be seen on the crater floor. Closely adjoining, above and to the right, are the three peaks of Teneriffe. Near them, and just above Plato, the 8,000-foot isolated mountain Pico casts its shadow across Mare Imbrium. The ridges in this sea show up very well between Plato and Archimedes. The shadow cast by the 4,000-foot wall of the latter crater is well seen, as is the detail in the foothills to its south.

Going farther south, one finds the magnificent Apennine Mountains, with their brightly sunlit northern ramparts and more gradual southern slopes. Slightly above the midpoint of the terminator is the giant ring plain Ptolemaeus, with jet-black and razor-sharp interior shadows. The interior craterlet, immediately above a shallow depression, is only five miles in diameter.

The next crater to the south is 70-mile-diameter Alphonsus, whose faulted floor can be seen, as well as the thin shadow thrown leftward by its central peak. The last crater in this group of three is Arzachel, deeply shaded. Here also a mountain in the center throws a long shadow westward, partly obscuring a small crater.

A little farther up is Purbach with its three interior hills, and about 50 miles east is the south end of the Straight Wall. Far above this is the huge crater Clavius, about 150 miles in diameter, with much interior detail. Nearer the moon's limb, the central peak of 75-mile Moretus



The terminator portion of Max Collin's photograph of the moon, made with his 12½-inch Springfield reflector.

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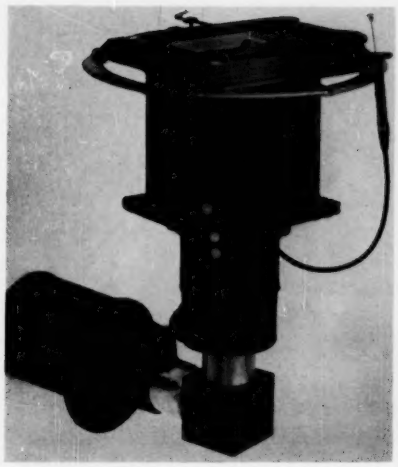


The camera attachment is here shown inserted into the eyepiece holder at the lower left. The ground glass may be seen in the plateholder at the top of the picture.

shines like a star, illuminated by the eastern sun. At the very rim of the moon the giant Doerfel Mountains are seen in profile, with peaks over 20,000 feet.

This photograph was a $\frac{1}{2}$-second exposure on Kodak Plus X film, with a 6-inch off-center diaphragm so that the effective focal ratio was f/18. To avoid vibration, I did not use a mechanical shutter, but pulled a piece of black paper with a $\frac{1}{4}$-by-2-inch slit in front of the film. This precaution is probably responsible for the sharpness of the negative.

Experiments with filters gave less satisfactory results. Trials with exposure times from 1/100 to 1 second were made; the longer exposures worsen definition and the shorter ones make the moon too dark. I have also tried high-contrast plates. While they show more detail away from the terminator, at the terminator itself much is lost from the lack of shading; moreover, the maria came out too dark and not at all how they appear in a telescope. My purpose throughout was to show the moon as it actually looks telescopically.

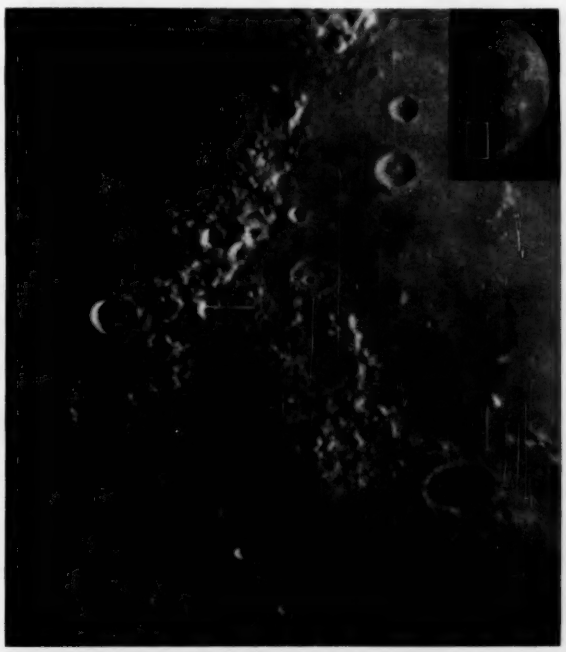
The other photograph was taken on November 15, 1954, at 3:54 a.m. CST. Kodak Super XX, which is twice as fast as Kodak Plus X, was used, exposure two seconds with the image projected through a 1½-inch eyepiece to enlarge this section of the moon. The exposure might have been a little too long.

The simple, homemade photographic attachment that I used replaces the eyepiece of the telescope. As shown in the picture, it consists of two cans, one sliding into the other. Focusing is by the rack and pinion below, and white dots of radium paint allow me to check the focal setting in the dark. The large ring surrounding the top of the camera is divided into 360 degrees, so that the orientation of each picture is known.

The guiding eyepiece is not seen in this photograph, as it is on the back side. Light from a guide star at the edge of the field is reflected by two small prisms, through a Barlow lens to lengthen the focus, to the eyepiece. The camera can be rotated so that I have 360 degrees in which to find a guide star. At the focal point there are crosshairs, and a tiny ring of luminous paint for centering the guide star.

The total cost of the attachment was $16.80, and it took about two weeks of my spare time to build.

MAX COLLIN
2316 E. 71st St.
Chicago 49, Ill.



This photograph was taken through an eyepiece, on November 15, 1954. The inset shows its location with reference to the last-quarter moon. The Caucasus Mountains show up well. Mr. Collin believes that the exposure was slightly too long for maximum sharpness. South is at the top.

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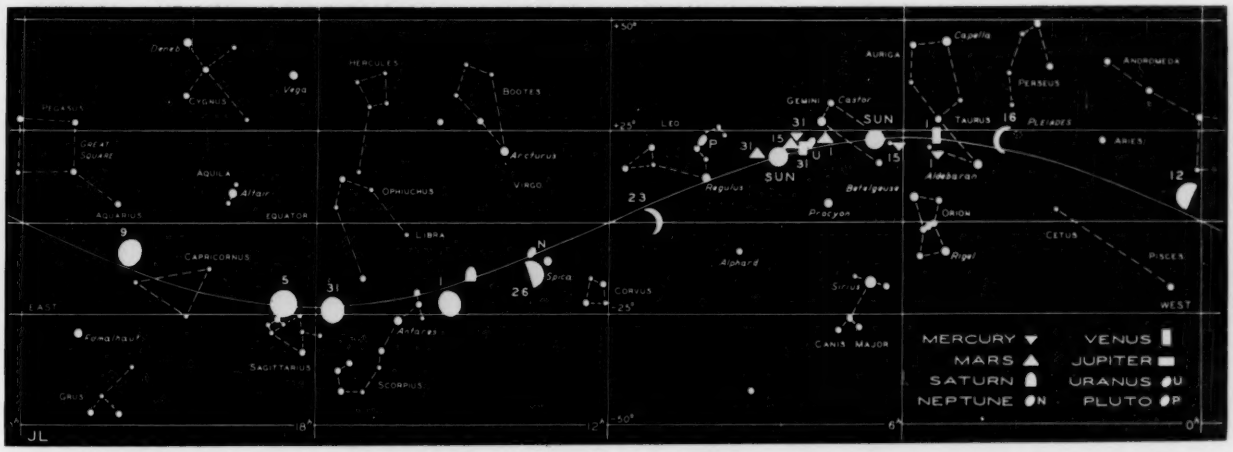

THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month and for other dates shown.

Mercury may be observed in the morning sky most of July, with greatest elongation occurring on the 9th. The planet will then be 21° 10′ from the sun, rising 1½ hours earlier, at magnitude +0.6. Mercury will brighten throughout the month, and stays west of Venus till July 28th. On the 18th, at 3:45 UT, the elusive planet passes only 5′ south of the moon, but the conjunction will not be visible in America, though the moon may be seen between Mercury and Venus that morning.

A conjunction with Venus takes place July 28th, with Mercury 20′ north. This may be difficult to observe, although Venus is bright and Mercury will be at magnitude −1.3. The pair rises three quarters of an hour before sunrise.

Venus will be seen in the morning sky for the last time until next year. Early in the month, it rises an hour before the sun, shining at magnitude −3.3.

Mars, though in the evening sky, is too close to the sun to be viewed this month.

Jupiter may still be located with difficulty during the first days of July. It will be very low in the western sky after sunset, a −1.3-magnitude object.

Saturn sets at midnight on July 23rd as seen from latitude 40° north. Its very slow motion, north of Alpha Librae, changes from westward to eastward on the 20th. In mid-July, the rings will be inclined 20°.6 to our view, and their longest diameter will be 39″.6.

Uranus passes conjunction with the sun on the 21st, and therefore cannot be seen this month.

Neptune can be found with optical aid during early evening hours in the western sky. This distant 8th-magnitude planet is about ½° west of 82 Virginis. Neptune is stationary in right ascension on the 8th.

E. O.

UNIVERSAL TIME (UT)

TIMES used on the Observer's Page are Greenwich civil or Universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the UT before subtracting, in which case the result is your standard time on the day preceding the Greenwich date shown.

MOON PHASES AND DISTANCE

Full moon	July 5, 05:28
Last quarter	July 12, 20:31
New moon	July 19, 11:34
First quarter	July 26, 15:59
Full moon	August 3, 19:30

	July	Distance	Diameter
Apogee	2, 09h	252,200 mi.	29′ 27″
Perigee	17, 20h	224,400 mi.	33′ 05″
Apogee	29, 22h	251,600 mi.	29′ 31″
	August		
Perigee	14, 18h	227,400 mi.	32′ 39″

PREDICTIONS OF BRIGHT MINOR PLANET POSITIONS

Nausika, 192, 8.2. July 12, 21:26.5 −23-46; 22, 21:19.7 −24-02. Aug. 1, 21:10.3 −24-15; 11, 20:59.4 −24-16; 21, 20:48.8 −24-02; 31, 20:40.3 −23-31.

Helena, 101, 9.8. July 22, 21:56.3 −22-34. Aug. 1, 21:48.0 −22-42; 11, 21:37.8 −22-41; 21, 21:27.2 −22-28; 31, 21:17.6 −22-02. Sept. 10, 21:10.4 −21-22.

Fortuna, 19, 9.3. July 22, 22:14.4 −8-17. Aug. 1, 22:09.1 −8-42; 11, 22:01.7 −9-22; 21, 21:52.9 −10-10; 31, 21:44.0 −11-02. Sept. 10, 21:36.3 −11-51.

After the asteroid's name are its number and the magnitude expected at opposition. At 10-day intervals are given its right ascension and declination (1950.0) for 0h Universal time. In each case the motion of the asteroid is retrograde. Data are supplied by the IAU Minor Planet Center at the University of Cincinnati Observatory.

SUNSPOT NUMBERS

April 1, 12, 9; **2,** 2, 14; **3,** 6, 8; **4,** 7, **21; 5,** 21, 36; **6,** 32, 30; **7,** 29, 32; **8,** 26, 31; **9,** 15, 19; **10,** 9, 10; **11,** 3, 0; **12,** 0, 0; **13,** 1, 0; **14,** 0, 0; **15,** 13, 7; **16,** 13, 9; **17,** 5, 13; **18-19,** 0, 0; **20,** 3, 0; **21,** 2, 8; **22,** 1, 0; **23,** 1, 0; **24,** 1, 8; **25,** 0, 0; **26,** 2, 0; **27,** 14, 10; **28,** 21, 22; **29,** 25, 23; **30,** 26, 29. Means for April: 9.7 American; 11.3 Zurich.

Above are given the date, the American number, then the Zurich number. These are observed mean relative sunspot numbers, the American computed by D. W. Rosebrugh from AAVSO Solar Division observations, the Zurich numbers from Zurich Observatory and its stations in Locarno and Arosa.

Dr. M. Waldmeier, of Zurich Observatory, has made the following predictions of the smoothed monthly sunspot numbers for the next few months: July, 16; August, 18; September, 19; October, 21.

The Swiss Broadcasting Corporation regularly transmits by short wave the Zurich provisional sunspot numbers for the preceding month. Listeners in North America can receive these reports on the 5th of each month at 01:35 and 04:20 UT on 48.66, 31.46, and 25.28 meters wave length. This new schedule is effective through August, 1955.

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OCCULTATION PREDICTIONS

July 1-2 **19 Scorpii** 4.8, 16:17.9 −24-03.7, 12, Im: **A** 5:43.0 −1.6 −2.0 118; **C** 5:42.5 −1.9 −2.0 121; **D** 5:29.9 −1.7 −1.5 110; **E** 5:12.3 −2.2 −1.2 110; **F** 5:07.8 −2.7 −1.7 127; **H** 4:12.6 −1.7 −0.5 129.

July 3-4 **4 Sagittarii** 4.8, 17:57.0 −23-48.8, 14, Im: **A** 2:14.7 −2.3 +2.4 37; **B** 2:19.4 . . . . . 30; **C** 1:56.4 −2.2 +2.2 49; **D** 2:02.4 −2.1 +2.5 40.

July 15-16 **Tau Tauri** 4.3, 4:39.5 +22-52.3, 26, Im: **E** 10:04.4 −0.5 +0.9 100; **F** 9:55.8 −0.4 +0.2 116. Em: **F** 10:40.5 +0.2 +2.2 221; **H** 10:51.0 +0.2 +1.1 263; **I** 11:04.4 −0.1 +0.9 295.

For stations in the United States and Canada, usually for stars of magnitude 5.0 or brighter, data from the *American Ephemeris* and the *British Nautical Almanac* are given here, as follows: evening-morning date, star name, magnitude, right ascension in hours and minutes, declination in degrees and minutes, moon's age in days, immersion or emersion; standard station designation, UT, **a** and **b** quantities in minutes, position angle on the moon's limb; the same data for each standard station westward.

The **a** and **b** quantities tabulated in each case are variations of standard-station predicted times per degree of longitude and of latitude, respectively, enabling computation of fairly accurate times for one's local station (long. **Lo**, lat. **L**) within 200 or 300 miles of a standard station (long. **LoS**, lat. **LS**). Multiply **a** by the difference in longitude (**Lo** − **LoS**), and multiply **b** by the difference in latitude (**L** − **LS**), with due regard to arithmetic signs, and add both results to (or subtract from, as the case may be) the standard-station predicted time to obtain time at the local station. Then convert the Universal time to your standard time.

Longitudes and latitudes of standard stations are:

A	+72°.5,	+42°.5	**E**	+91°.0,	+40°.0
B	+73°.6,	+45°.5	**F**	+98°.0,	+31°.0
C	+77°.1,	+38°.9	**G**	Discontinued	
D	+79°.4,	+43°.7	**H**	+120°.0,	+36°.0
			I	+123°.1,	+49°.5

MAGNIFICATIONS FOR MESSIER OBJECTS

During the past year I have been observing clusters and nebulae in Messier's list, and have kept a record of which magnifying power shows each object best. With my 6-inch f/8 reflector I use eyepieces of 1¼, 1, ½, ⅜, and ¼ inches, yielding powers of 38, 48, 96, 144, and 192, respectively.

The following list gives the magnifications I have found best for the most easily reached Messier objects. Their right ascensions and declinations are tabulated on pages 158 and 159 of the March, 1954, *Sky and Telescope*.

38x and 48x: M1, 6, 7, 17, 20, 21, 27, 31, 33, 35, 37, 38, 39, 41, 46, 50, 51, 64, 65, 66, 76, 78, 81, 82, 93, 94, 97, 101.

96x: M2, 4, 5, 15, 22, 57.

144x and 192x: M3, 13, 92.

Several Messier items are pleasing sights over a wide range of magnification. For the Orion nebula, M42, I use powers of 38, 48, and 96; and the open cluster M11 in Scutum and the globular M80 in Scorpius are good from 38 or 48 power to 192.

This information has helped me show deep-sky objects to neighbors and friends in a way that excites their interest.

MICHAEL MORROW
17 Crescent Hill Drive
Havertown, Pa.

VARIABLE STAR MAXIMA

July 4, T Aquarii, 204**05**, 7.9; 7, R Reticuli, 043**26**3, 7.7; 16, R Normae, 152**84**9, 7.2; 18, S Hydrae, 084803, 7.9; 25, V Cancri, 081617, 8.0; 27, R Lyncis, 065355, 7.9; 31, U Ceti, 022**81**3, 7.5. August 6, Z Ursae Majoris, 115158, 6.6; 8, V Canum Venaticorum, 131546, 7.1.

These predictions of variable star maxima are by the AAVSO. Only stars are included whose mean maximum magnitudes are brighter than magnitude 8.0. Some, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for maximum. The data given include, in order, the day of the month near which the maximum should occur, the star name, the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern), and the predicted magnitude.

JULY METEORS

The Delta Aquarid meteor shower will be at maximum on July 31st, when under ideal conditions 20 meteors would be counted per hour. However, the moon is well past first quarter, setting about 2 a.m. standard time; and the actual rate will be further reduced for United States observers by the low altitude of the radiant, which is at right ascension $22^h\ 40^m$, declination −15°. The relatively slow-moving Delta Aquarids can be best observed in the predawn hours. E. O.

MINIMA OF ALGOL

July 1, 23:18; 4, 20:06; 7, 16:54; 10, 13:43; 13, 10:32; 16, 7:21; 19, 4:09; 22, 0:58; 24, 21:46; 27, 18:35; 30, 15:24. August 2, 12:13; 5, 9:01; 8, 5:50.

These minima predictions for Algoi are based on the formula in the 1953 *International Supplement* of the Krakow Observatory. The times given are geocentric; they can be compared directly with observed times of least brightness.

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Low-Expansion Elliptical Diagonals—Aluminized

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¾"	$3.75	High quality, made of low-expansion glass, flat to ⅛ wave. Edges accurately ground to a perfect ellipse. Try using a smaller diagonal than you already have and watch the contrast, clarity, and sharpness of your image improve.
1"	3.75	
1¼"	5.00	
1½"	6.50	

Please include postage with order. *Free catalog sent on request.*

NYE OPTICAL COMPANY
2100 Cherry Avenue Long Beach 6, Calif.

Reciprocating Polishing Machines up to 12"

★

CHARLES RIDELL 48 Walworth Ave., Williams Bay, Wisc.

What! Not Another Contest?

The last "Caucus-race" contest proved to be great fun for all. So many interesting letters were received — which provided a refreshing change from our usual mail consisting of all those orders for UNITRON 4" Photo-Equatorials — that we have been looking for a suitable excuse to launch another contest. An idea finally came to mind as a result of a letter received from UNITRON owner S.F., of Norwalk, Calif., who wrote:

"When I received my UNITRON 2.4" Refractor a few months ago, I started a small club. By now, it has grown in size and we feel the need for another telescope. My 2.4" gives superb definition and I am very much satisfied with its performance. I feel that no other scope could take the place of a UNITRON. Please enter my order for another UNITRON 2.4" Altazimuth and include a UNIHEX. I feel it will be very useful to our club."

To help dramatize the important role that clubs play in amateur astronomy, we have decided to sponsor a contest open to members of clubs, with the grand prize to be presented to the club itself. To enter, merely write us a letter stating what use your club could make of a UNITRON Model 114 2.4" Altazimuth. The prize will, appropriately enough, consist of a Model 114 presented to the club and a UNIHEX for his own telescope to the writer of the most interesting and convincing letter. Ten additional prizes will be awarded to runners-up as follows: 2 UNITRON 10x 42-mm. view finders; 2 UNITRON 200x microscopes (yes, we also sell microscopes which range in price from about $11 to $1100); 2 UNITRON 8x 30-mm. view finders; 2 UNITRON 6x 23.5-mm. view finders; 1 binder for holding 12 back copies of **Sky and Telescope** (so our series of UNITRON ads can be easily consulted); and lastly, 1 bottle of UNITRON mosquito repellent (one of our new secret products and indispensable for summer observing).

The following information will be helpful to entrants:

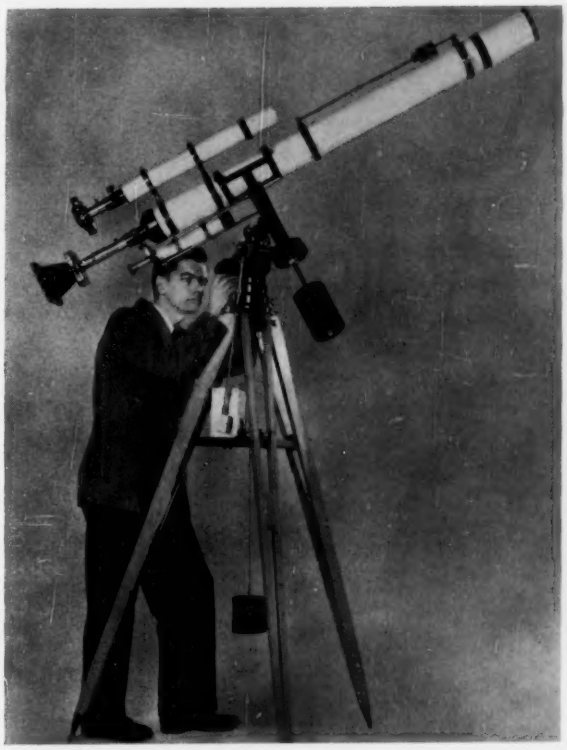
1. It costs nothing to enter. You do not have to send in a dewcap from a UNITRON. And for heaven's sake, don't try to butter up the judges by ordering something.

2. Any number of individuals may enter but they must all be members of bona fide clubs. While we wish to encourage the formation of clubs, the judges will probably take a dim view of one-man clubs hastily organized for purposes of entering this contest. With your entry, please give the name of your club, the length of time it has been in existence, the number of members, and the name and address of your club secretary. Your club need not be a large one, and junior clubs are naturally welcomed.

3. Entries must be received by August 10th. The judges will announce the winners in the October issue. (Incidentally, the judges used in the last UNITRON contest have since made a significant contribution to a Dodo stew and are, alas, unable to offer their services at this time. Another panel will be chosen.)

Good luck!

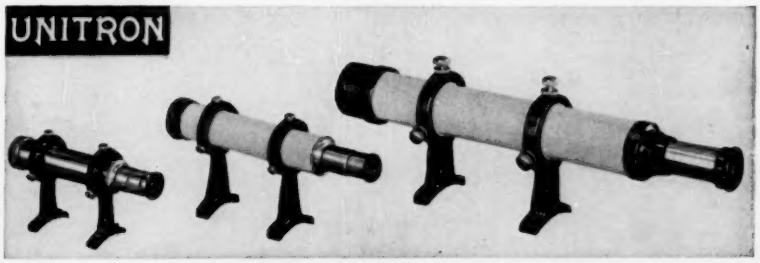
A Further Look at the New UNITRON 4" Photo-Equatorial



Last month, on the back cover, we gave you an at-the-controls view of UNITRON Model 166, the forthcoming 4" Photo-Equatorial with fixed pier, clock drive, and astro-camera. Shown above is the identical instrument with a portable field tripod in place of the metal pier. The weight-driven clock drive is ideal for portable use, since no electric current is required. This same mounting with controls for slow and rapid motion in both declination and right ascension is used on our regular 4" Equatorials, and smaller versions are on our 3" and 2.4" models.

Price and delivery on the new 4" models will be announced as rapidly as conditions permit. Advance information will be sent on request.

Modernize Your Telescope with Components by UNITRON



L. to R.: (1) 23.5-mm. 6x finder; (2) 30-mm. 8x finder; (3) 42-mm. 10x finder

1. VIEW FINDER (As used on UNITRON 2.4" Equatorial): 23.5-mm. (.93") achromatic objective, 6x eyepiece with crosshairs. Chromed brass tube. Mounting brackets with centering screws. **Only $8.50 postpaid**

2. VIEW FINDER (As used on UNITRON 3" Refractors): 30-mm. (1.2") coated achromatic objective and 8x eyepiece with crosshairs. Other details as in View Finder 3. **Only $10.75 postpaid**

3. VIEW FINDER (As used on UNITRON 4" Refractors): 42-mm. (1.6") coated achromatic air-spaced objective. 10x eyepiece with crosshairs. Duraluminum tube finished in white enamel. Dewcap. Furnished with mounting brackets with centering screws for collimation. This finder also makes an excellent hand telescope for spectacular wide-field views of the sky. **Only $18.00 postpaid**

SUN PROJECTING SCREEN APPARATUS: White metal screen with matching black metal shade. Chromed brass extension rod with mounting brackets.

Set with screen 6" x 6" **Only $13.50 postpaid**
Set with screen 7" x 7" **Only $15.75 postpaid**

PHOTOGRAPHIC GUIDE TELESCOPE (Illustrated in photo above): 62-mm. (2.4") diam., 700-mm. (27.5") focal length, coated, air-spaced, achromatic objective. 78x (9-mm.) achromatized Ramsden eyepiece with crosshairs. Star diagonal. Duraluminum tube finished in white. Dewcap. Rack-and-pinion focusing. Mounting brackets and centering screws for collimation. Fitted wooden cabinet. **Only $75.00 f.o.b. Boston**

EQUATORIAL MOUNTING and TRIPOD: Complete with slow-motion controls for both declination and R. A., setting circles and verniers, and many other features. Write for complete description.

As used on UNITRON 3" Refractor **$198**
As used on UNITRON 4" Refractor **$370**
(These prices are f.o.b. Boston)

See page 386 and the back cover.

United Scientific Co. 204-206 MILK STREET, BOSTON 9, MASS.

DEEP-SKY WONDERS

IN THE Scorpius-Sagittarius area lie large numbers of globular clusters. Between 16 hours and 18 hours of right ascension, and from declinations −20° to −40°, there are no less than 18 such clusters. The brighter Messier objects are well known and easily located, but the smaller globulars are no less observable if one has the Skalnate Pleso atlas.

At 16^h 14^m.1, −22° 52′ (1950), is NGC 6093, M80, discovered by Méchain. Its diameter is 5′ and its visual magnitude 7. Rather compressed, it is sometimes overlooked, but AAVSO observers know it because the long-period variable stars R Scorpii and S Scorpii lie in the same field. The AAVSO chart of this field makes a useful and quite beautiful possession.

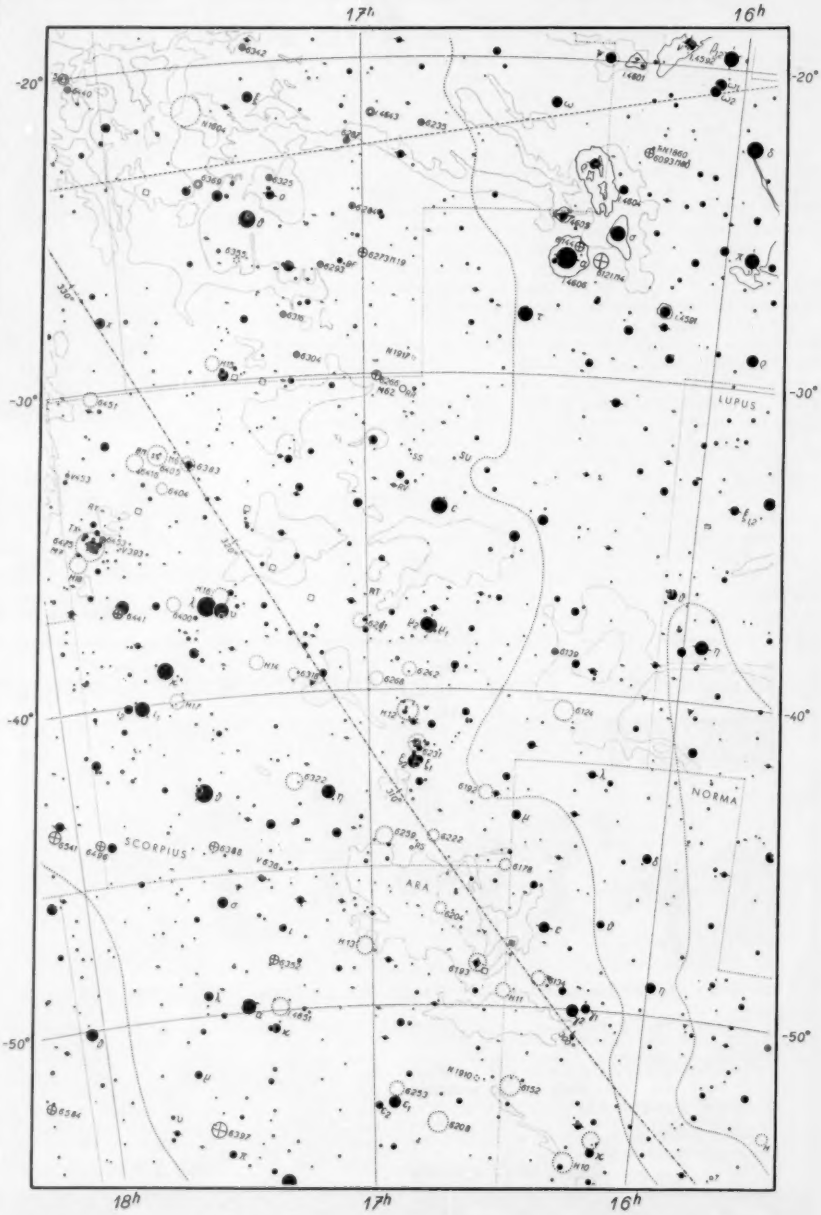
Better known is NGC 6121, M4, at 16^h 20^m.6, −26° 24′, fully 23′ in diameter, and visual magnitude 6 – a perennial favorite. It completely overshadows nearby NGC 6144 at 16^h 24^m.2, −25° 56′, a 10th-magnitude object 3′.3 in diameter. This little globular is a fine test for atmospheric transparency. Antares, M4, and NGC 6144 form a close triangle.

Much farther south and too low for many telescopes in the United States lies NGC 6139, at 16^h 24^m.3, −38° 44′. Free of the star clouds of the Milky Way, it is not lost in the star field. However, it is small, 1′.3 in diameter, and magnitude 10, requiring a medium power and careful sweeping to locate it. From southern latitudes it apparently is a fairly easy object.

The whole southern portion of Scorpius is an unfamiliar region to most amateurs, but with favorable atmospheric conditions and modern charts, exploration below Antares will repay any observer, old or new, as the photograph opposite shows.

WALTER SCOTT HOUSTON

FACING PICTURE: Almost the entire constellation of Scorpius is included in this reproduction of a Harvard Observatory patrol photograph. The same area is covered in the chart below, which will serve for identifying objects in this rich portion of the southern Milky Way.



This key chart is reduced from the Skalnate Pleso atlas. Dots show stars down to magnitude 7.75; crossed circles represent globulars; bright and dark nebulae are outlined by solid and dotted lines, respectively.

SKY-GAZERS EXCHANGE

Classified advertising costs 15 cents a word, including address; minimum charge, $3.00 per ad. *Remittance must accompany order.* Insertion is guaranteed only on copy received by the 20th of the second month before publication; otherwise, insertion will be made in next issue. We cannot acknowledge classified ad orders. Sky Publishing Corporation assumes no responsibility for statements made in classified ads, nor for the quality of merchandise advertised. Write Ad Dept., Sky and Telescope, Harvard Observatory, Cambridge 38, Massachusetts.

TELESCOPES and all accessories bought, sold, or exchanged. Valley View Observatory, 106 Van Buren St., Pittsburgh 14, Pa. Established 25 years ago.

SPECIAL: 1¼″ elliptical flats, ¼ wave, with metal cell, $2.00 bare, $2.50 aluminized. Harold Snyder, 705 Leopold St., Huntington, Ind.

FOR SALE: Brass rack-and-pinion eyepiece holder, 2″ movement, takes standard 1¼″ eyepiece. Price $5.95 postpaid. Satisfaction or money refunded. Donald Lehr, 31 S. Hood Ave., Audubon 6, N. J.

SIDEREAL WATCH: 25-jewel Longines, 2 dials 2 x 4 inches, A-1. $95.00. Photos available. B. Waeck, 101 Wendover Rd., Baltimore 18, Md.

ASTRONOMICAL SLIDES 35-mm. for teachers, lecturers, or amateurs. Only 20¢ each. Free catalogue. Martin Kantor, 129 Rockaway Parkway, Brooklyn 12, N. Y.

FOR SALE: 3″ refracting telescope with three eyepieces: 45x, 50x, and 114x. Will consider offers $135.00 and up. Robert Stearns, Sunset Bluff, Largo, Fla.

WANTED: Used 10″ telescope or larger, or parts for the above scopes in good condition. Write to James Jennings, 129 E. Virginia, Walters, Okla.

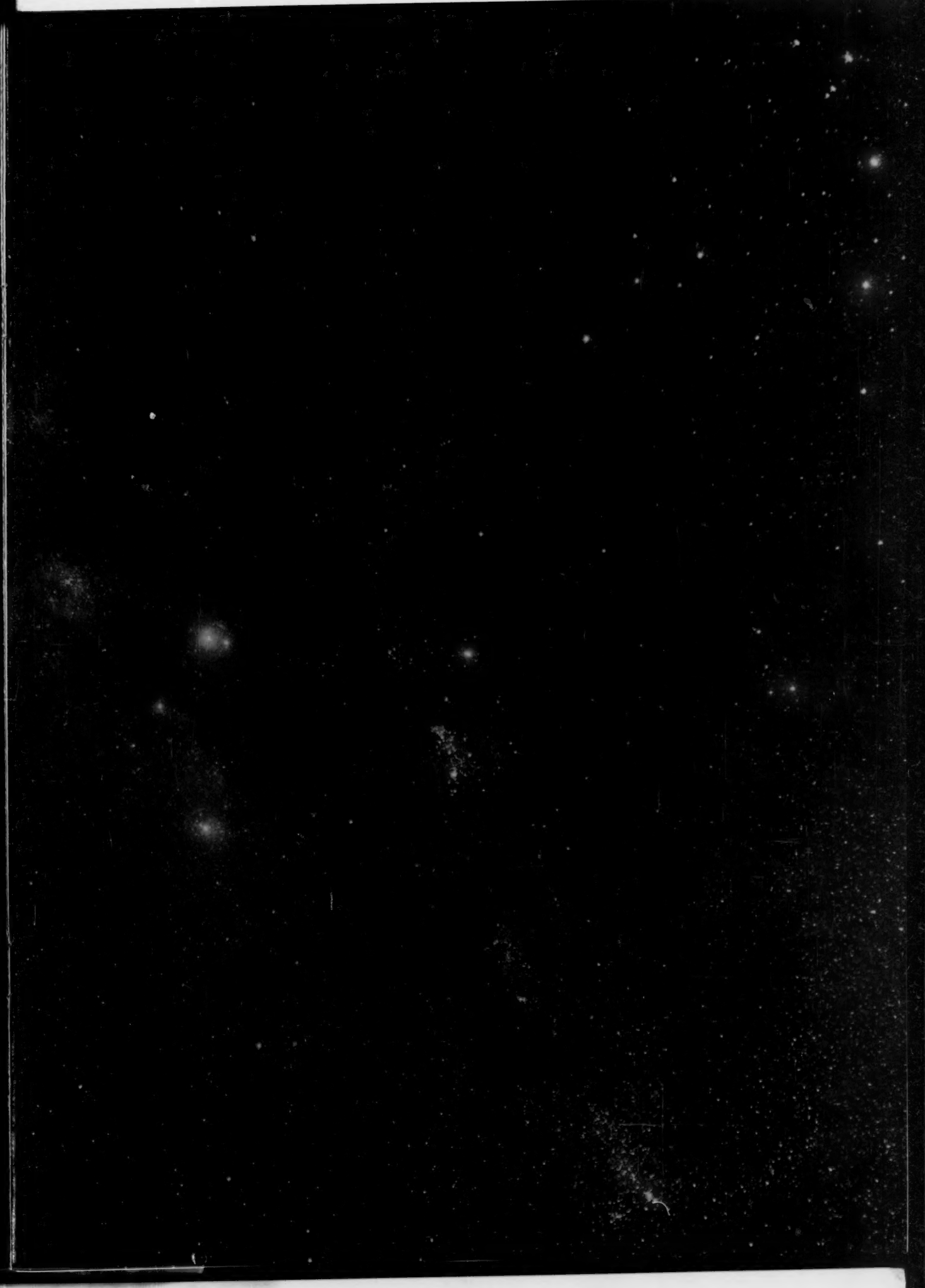
AMATEUR ASTRONOMER'S *Handbook*, $12.50, write for leaflet; Norton's *Star Atlas*, $5.25; *Bonner Durchmusterung*, northern parts, $62.50; southern parts, $38.50; Cox, *Photographic Optics*, $5.75; Wilkins, *Our Moon*, $2.75. All foreign and domestic publications. Request new list. Herbert A. Luft, 42-10 82nd St., Elmhurst 73, N. Y.

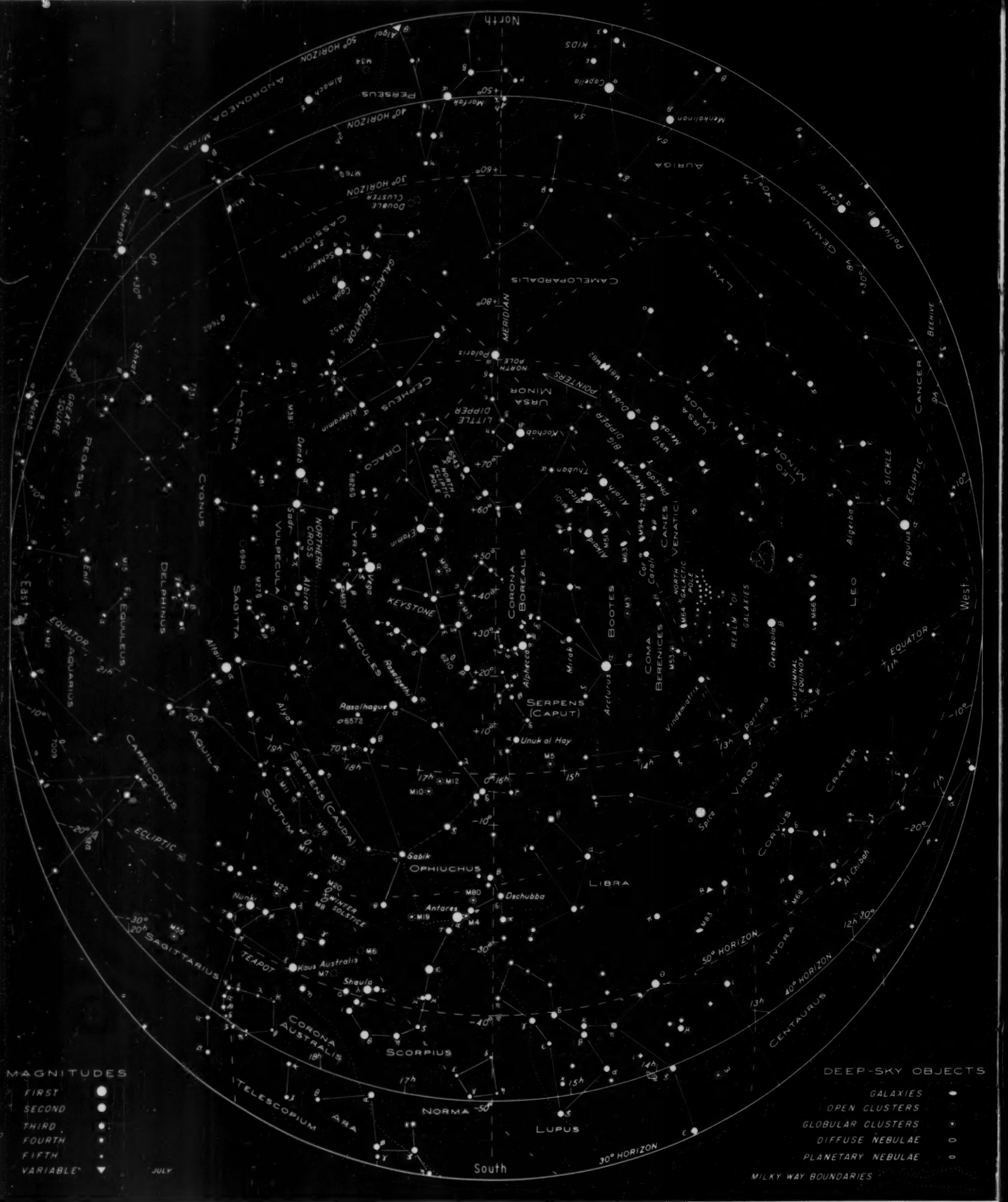
FREE BOOK bonus. Choose $10.00 worth of astronomical books from our list of over 80 titles and these will be sent absolutely free with your order for a B-107 Sans and Streiffe refractor for $95.00. We also supply Unitrons, all models, and 6″, 8″, and 10″ Astrola reflectors. Write for lists. Rasmussen and Reece, Amsterdam, N. Y.

PROFESSIONALLY MADE, 8″ f/8 mirror. Excellent performance, perfect condition, Beral coated. $50.00. L. Myers, 472 Twin Oaks Rd., Union, N. J.

PLATE GLASS mirror, 14½″ by 1″ thick, f/6, nice figure. $175.00. Will require sufficient mounting to avoid distortion. New design circular spider to hold any of our elliptical diagonals, $8.00. Gives excellent results. State your diagonal and tube sizes. Nye Optical Co., 2100 Cherry Ave., Long Beach 6, Calif.

WANTED: A complete set of *Sky and Telescope*, Vols. I through VIII, in condition suitable for binding. Write price. Box A, Sky and Telescope, Harvard Observatory, Cambridge 38, Mass.



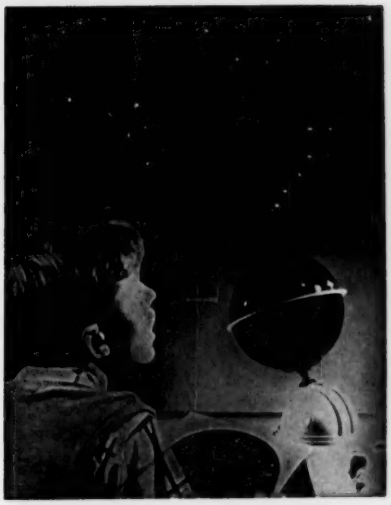


STARS FOR JULY

The sky as seen from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., local time, on the 7th and 23rd of July, respectively; also, at 7 p.m. on August 7th. For other dates, add or subtract ½ hour per week.

The X of faint stars that marks the head of Serpens is high on the meridian this month, with the Serpent's body stretching south and east. The constellation is divided into two unconnected parts, Serpens Caput, its head, and Serpens Cauda, the tail.

Spitz Jr. Planetarium



No. 701 Spitz Junior Planetarium. A new visual teaching aid brings a knowledge of the heavens into your classroom or home. A plastic globe is perforated with small apertures and contains a pinpoint light source inside. Stars and constellations are projected on the ceiling; a dome is helpful, but not necessary. Adjustable for date and latitude. Size 14½" high, 7½" square base. Weight 3 lbs. Operates on 110-volts. Complete with 32-page star guide. **$15.00**

Celestial Globes

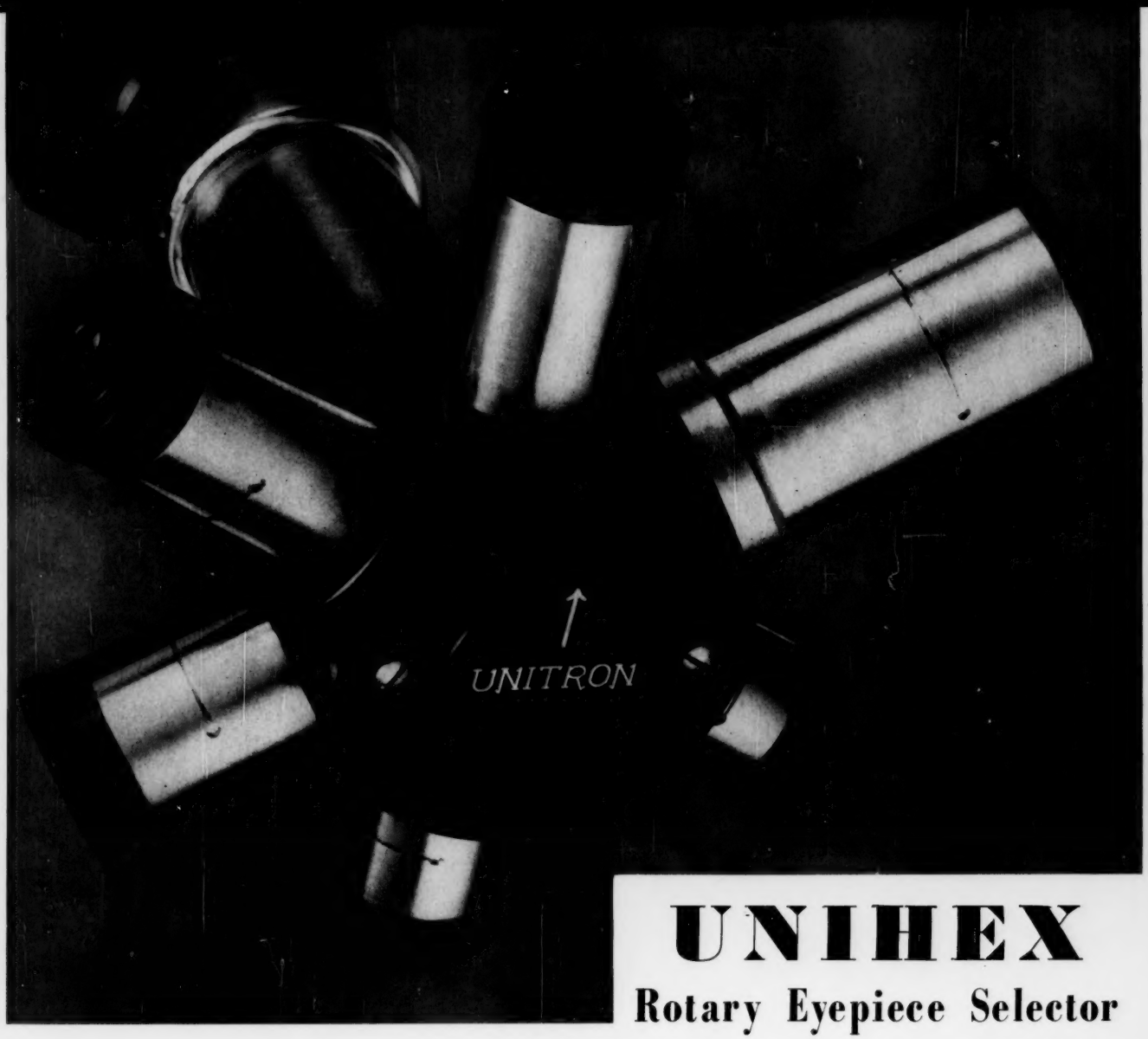
No. 740-5 Deluxe Celestial Globe. Our finest 16" globe was designed as a visual aid by teaching astronomers. All stars of the first six magnitudes are shown on a pale blue background, with the first three magnitudes having bright yellow circular backgrounds. Brighter stars named and constellation boundaries indicated. Declination and right ascension circles printed in black. Magellanic Clouds and Milky Way stand out in white; important star clusters indicated. Weighted table base, movable meridian with horizon. (Other mountings available.) **$67.50**

No. 731 Celestial Globe. This full 9" diameter globe has an attractive base and setting that makes it ideal for display in the schoolroom or home. A dark blue background makes the yellow stars stand out for easy recognition. Stars to the sixth magnitude included. Ecliptic and equator emphasized. Constellation outlines and mythological figures in light blue. Movable meridian for latitude. Brown plastic cradle supplies horizon as well as effective base. With handbook. **$14.50**

No. 732 Little Dipper Globe. A teaching aid that is designed to introduce the wonders of the heavens to all youngsters, and it will fascinate grown-ups too. The all-metal 6" celestial globe brings out the mythological background of the constellations in five brilliant colors and shows all major stars and constellations, the equator and the ecliptic. A meridian circle and a convenient base are included. Popular 155-page book "Stars" in full color is included to give further material on the mysteries of astronomy. Overall height 8½"; shipping weight 2½ lbs. **$4.00**

SCIENCE ASSOCIATES

194 Nassau Street **Box 216** **Princeton, N. J.**



UNIHEX

Rotary Eyepiece Selector

NOW AVAILABLE WITH UNITRONS AT NO EXTRA COST!

How do you change magnification in your telescope?

The old-fashioned method of fumbling with eyepieces in the dark has been outmoded by UNIHEX, UNITRON's new Rotary Eyepiece Selector. With UNIHEX, you always have 6 magnifications ready at your fingertips. To change power, merely rotate a new eyepiece into position while the object stays centered and in focus in the field of view. Think how much this valuable aid can contribute to your increased comfort and relaxation while observing.

Now, effective immediately, you may obtain a UNIHEX with your UNITRON as standard equipment at no increase over the regular purchase price. On request, we will substitute UNIHEX in place of the star diagonal and erecting prism system (in all models except No. 127). Either or both of these accessories may be purchased separately, if desired, at any time.

UNIHEX is but one of a number of significant new accessories designed especially for UNITRONS. The ingenious design and careful workmanship of these accessories are characteristic of UNITRONS themselves and distinguish them from all other refractors of equal aperture. Just one more reason why you'll be glad that your telescope is a UNITRON.

Present UNITRON owners may bring their telescopes up to date with UNIHEX-A, designed to replace the customary 36.8-mm. O.D. drawtube in the UNITRON rack-and-pinion focusing sleeve. Owners of other telescopes may now obtain UNIHEX-B which fits into 1¼" eyepiece holders. Both Models A and B are priced at only $24.75 postpaid.

See pages 386 and 395.

United Scientific Co.

204-206 MILK STREET,
BOSTON 9, MASS.